Rahul
BONNEYVILLEMILLS
ESTABLISHED
1832
The MOST
Wonderful
A4 SPIRAL
Note Book

Zoology

class ÷ 11th

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# Structural organization in animals

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## * Introduction

Cell → Tissue → Organ → Organ-system → organism

- Cell ÷ Cell is the structural and function-al unit of life
- Tissue ÷ Tissue is a group of similar cells with intercellular matrix that perform specific function.
- Organ ÷ When different types of tissue organize in specific pattern and proporation that is called organ.
ex: heart, kidney etc
- Organ-system ÷ When different organs interact and work together physically and chemically, it is called organ-system.
ex: digestive system

Organism ÷ Many organ-system work together and form organism

* Organism (two- types)

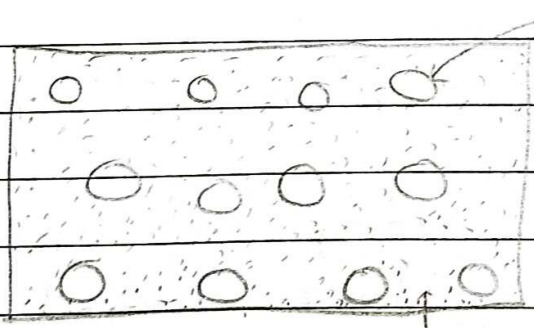
<1> Unicellular organism
→ Organism is made of single cell.
→ All works done by single cell
ex: amoeba

<2> Multicellular organism
→ Organism is made of many cells
→ Division of labour is present, it mean works are divided among cell.
ex: human

different types of cell and each type of cell has types

- Hydra is made of thousand of cells
- Human is made of billions of cells

* Intercellular matrix
→ The matrix which is present b/w cells.



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* Types of tissue (on the basis of structure and function)

There are four types of tissue

<1> Epithelium tissue
- "Origin: ~~Ectomeso~~ Ectoderm, mesoderm and endoderm"
- provide lining, covering and protection

<2> Connective tissue
- "Origin: mesoderm"
- helps in transport of material, connect structures

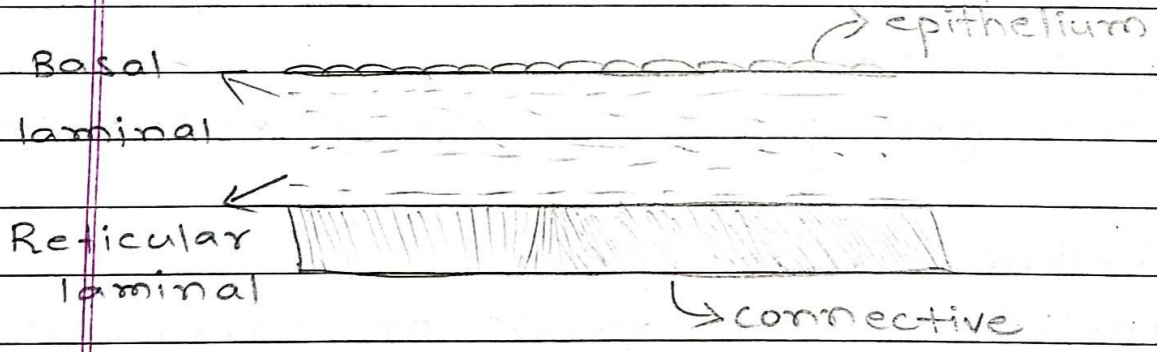
<3> Muscular tissue
- "origin: mesoderm"
- perform locomotion and movement

<4> Neural tissue
- "Origin: ectoderm"
- Detect, generate and carry nerve impulse

* Epithelium tissue
- Epithelium tissue grow on other tissue (connective-tissue)
- "Avascular in nature" (no blood vessels)

- Neural supply is present
- Take nutrients from connective tissue
- "Power of regeneration is present"
- Cells are compactly packed with little intercellular matrix
- "In embryo first tissue that form is epithelium"
- "Epithelium orginate from all three layer ecto, meso and endoderm"

* Basement membrane
B/w epithelium and connectide tissue a non-cellular layer is present called basement membrane




Basement membrane = Basal lamina + Reticular lamina

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* Function of epithelium tissue

- provide lining and covering
- protection
- diffusion/exchange of materials
- filtration

* Types of epithelium tissue

There are two types of epithelium tissue

<1> Simple epithelium
- unilayered cells
- function: diffusion, filtration, secretion and absorption

<2> Compound epithelium
- multilayered
- function: mainly protection

* Free surface modification in epithelium

There are two types of modification

<1> Microvillia:

→ For motion of finger like projection from cell

- Also called brush- boardered cell
- Microvillia increase surface area which mean more secretion and absorption

(2) Cilia :

- Formation of hair like structure from cell.
- Also called ciliated epithelium.
- Cilia helps in movement of particle in one direction only.
ex: movement of mucus in bronchiole

* Types of simple epithelium

There are three types of simple epithelium

(1) Simple squamous

(2) Simple cuboidal

(3)

(3) Simple columnar

• Polygonal shape → A 2D structure with more than 2 sides.

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Germ cell = Gonad = gamete = Sperm & ova

## * Simple squamous epithelium

- "Cells are polygonal in shape"
- "Nucleus is present in the centre."
- "Irregular boundary (tessalate epithelium)"
- "Aslo known as pavement epithelium"

- Function: diffusion of gas/material, filtration
- "Location: alveoli of lungs, Bowan's capsule of nephrons."
- "provide lining to blood vessels."

## * Simple cuboidal epithelium

- Cube like cells arranged in single layer.
- "Also called germinitive epithelium because it is found in testes and ovary and also formed sperm and ova (germ cell)"
- "location: testes, ovary, fullicle in thyroid gland."

## * Modification of simple cuboidal epithelium

(1) Brush-bordered cuboidal

- microvillia is present
- "location: PCT of nephron."

(2) Ciliated cuboidal
- Cilia is present
- "location: bronchiole of lungs"

* Simple columnar epithelium
- "Tall and slender cells are arranged in single layer"
- "nucleus is present at base (basal nucleus)"
- Function: secretion and absorption
- "location: stomach, gall blader"

* Modification of simple columnar

(1) Brush bordered columnar
- microvillia is present
- "location: intestine"

(2) Ciliated columnar
- Cilia is present
- "location: fallopian tube"

* Glandular epithelium

- Few columnar or cuboidal cell release substance like hormone, enzymes, sweat oil etc and they are called as glandular epithelium

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* Types of gland (on the basis of number of cell)

(1) Unicellular gland: one cell secrete substance.
ex: "goblet cell" (release mucus)
↳ modification of columnar-cell

(2) Multicellular gland: Cluster of cells release substance.
ex: "salivary gland"

* Types of gland
(on the basis of secretion of substance)

(1) Exocrine gland (duct gland): substance release in ducts (liver is an example)
"ex: enzymes, saliva, earwax, oil"

(2) Endocrine gland (ductless gland)
. Substance directly release in blood
"ex: hormone; gland ÷ adrenal gland"

(3) Heterocrine (mixed) gland
. Both exocrine and endocrine
"ex: ~~pane~~ pancreas gland"

* Pseudostratified epithelium

- Cells are arranged in one layer and appear as multilayer.
- Due to arrangement of cell, like multi-layer (some cells are short and some are long), it is known as pseudostratified
- "location: trachea (wind pipe)"

* Compound epithelium

- Cells are arranged in multilayer
- limited role in secretion and absorption. Main function is protection
- There are two types of compound epithelium.

(1) Stratified

(2) Transitional
→ have stretching ability
↳ expand and contract without damage.

* Stratified epithelium

. According to 1st layer, stratified epithelium have three types

<1> Stratified squamous
<2> Stratified cuboidal
<3> Stratified columnar
} non-kertainized

* Stratified squamous epithelium

<1> Kertinized ÷ Kertin (protein) is present
ex: skin

<2> Non-kertinized ÷ Kertin is absent
ex: ~~vagia~~ Vagina

* Cell junction

. Cell junction is structurally and functionally linkage/connection b/w cell.

* Types of cell junction

There are three types of cell junction

1) Gap junction

Connect cytoplasm of two cells, exchange of ions, molecule and sometimes big molecule
ex: Cardiac muscle

R <2> Tight junction
↳ prevent ~~teakg~~ leakage
· ~~Tight junction form a linkage that joins two cell tightly~~
ex: urinary bladder.

<3> Adhering junction

provide cementing b/w cells
ex: skin

*

· Cuboidal epithelium is found in ducts of gland and tubular parts of nephron in kidney.

· Ciliated epithelium (cuboidal and columnar) is present in inner lining of hollow organ, fallopian tube, bronchiole.

· Compound epithelium are present in dry surface of skin, moist surface of buccal cavity, pharynx, inner lining in ducts, salivary gland and pancreatic ducts.

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* Connective tissue
- "origin: mesoderm"
- "most abundant and widely distributed in our body."
- cells are normally packed with intercellular matrix.

* Function of connective tissue

(i) transport of material
(ii) connect different structure
(iii) provide support to body

* Components of connective tissue
There are three component of connective tissue

(1) Cells (four types)

(a) Fibroblast
- Secrete fibres + matrix
- more in cell number

(b) Macrophage ÷ phagocytosis/engulf

(c) Adipocyte ÷ fat store

(d) Mast cell ÷ release!

(i) serotonin
(ii) heparin
(iii) histamine

<2> Fibres (two types)
(a) collage (white): provide strength
(b) Elastic (yellow): provide elasticity

- One more fibre is there called - reticulate fibre (form network)

<3> Background substance ÷ present matrix

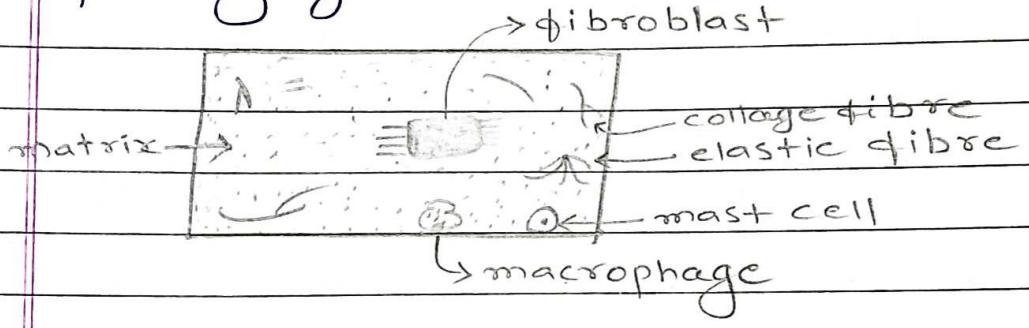
* Types of connective tissue
There are three types of connective tissue
<1> Loose C.T <2> Dense C.T <3> Specialised - C.T

* ~~Loss loos~~ Loose C.t
cells and fibres are loosely arranged in matrix

- Loose connective tissue has two types

(1) Areolar connective tissue

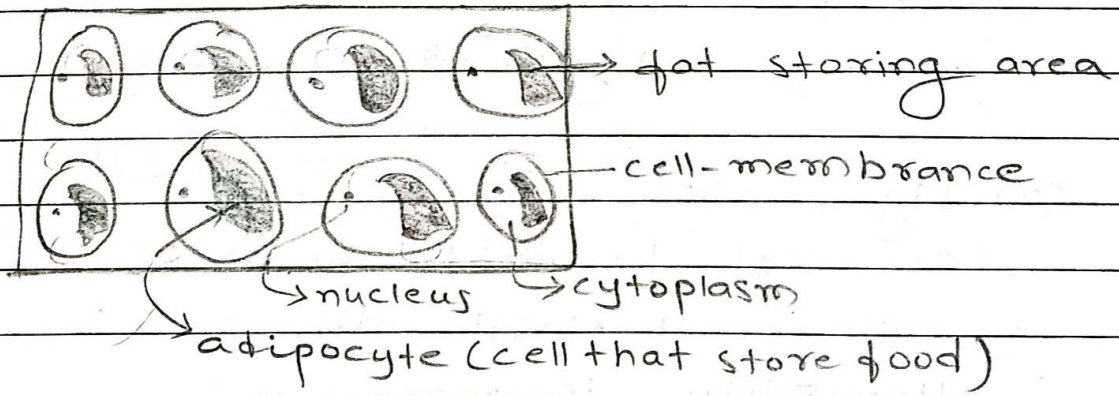
- Cells and fibres are loosely arranged
- provide support to epithelium.
- present beneath the skin
- packaging tissue




Note: Areolar connective tissue joins skin (intergument) with muscle.

(2) Adipose connective tissue

- present beneath the skin
- arranged internalvital organs (heart, kidney)
- Function: (i) release extra nutrient/fat
  (ii) provide insulation or heat
  (iii) protect internal vital organ

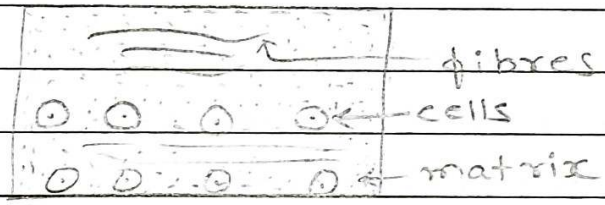


* Dense connective tissue
- Cells and fibres are compactly/tightly packed in matrix

- Based on arrangement of fibres and cells, dense connective tissue is of two types
(1) Dense regular (2) Dense irregular

* Dense regular connective tissue

- Cells are arranged in a pattern b/w bundles of fibres



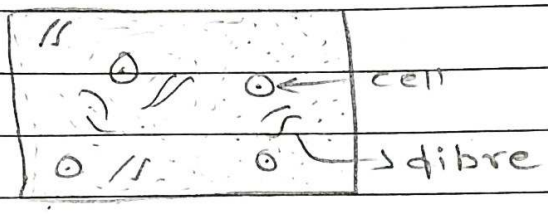

- Dense regular connective tissue is of two types

(1) Tendon: connect bone to muscle
- mostly collagen, strength is more

(2) Ligament:
- connect bone to bone
- collagen + elastic fibres
- flexibility is more

* Dense irregular tissue

- Cells and fibres are compactly packed
- Also cells and fibres are randomly present in matrix (no pattern)




* Specialised connective tissue (two types)
(1) Skeletal CT (2) Fluid CT

* Skeletal connective tissue
- matrix is solid
- fibres are present
- Skeletal CT have two types
(i) Bone (ii) Cartilage

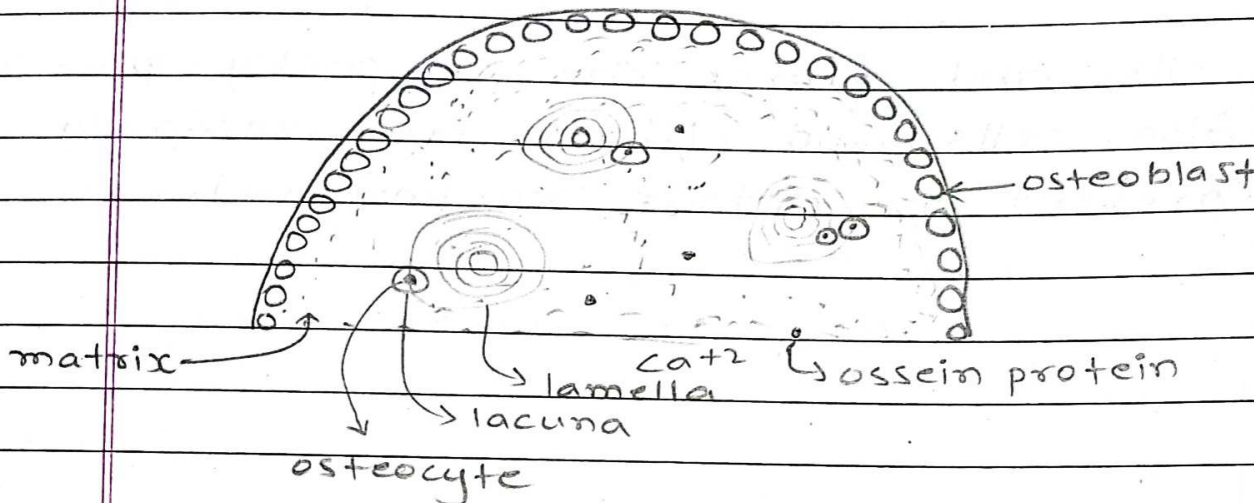
* Bone
- matrix : solid, hard, non-pilable (when we apply pressure, it breaks)

- matrix have two components
(i) organic : have ossein protein

(ii) Inorganic : have salt of $Ca^{2+}$, calcium sulphate, calcium phosphate.

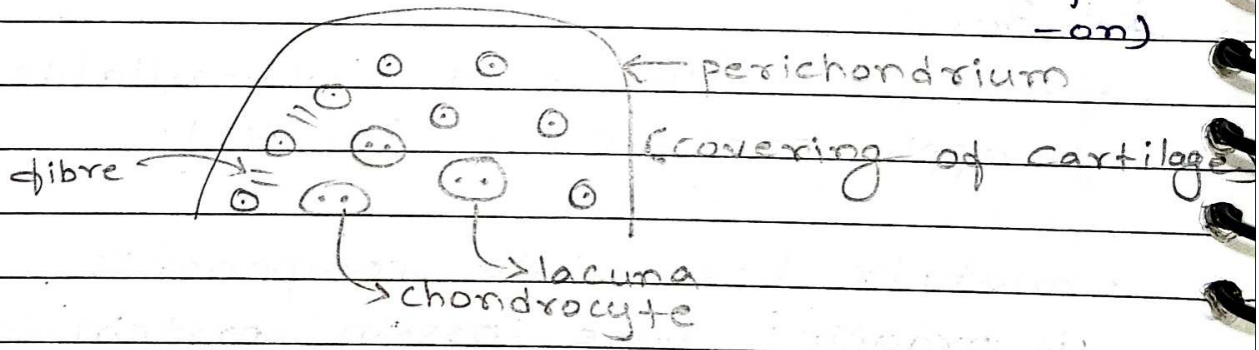
• Red bone marrow form RBCs, WBCs and ~~thrombo~~ + thrombocyt

• cells ÷ osteoblast, osteocyte, osteoclast




Note: In bone, lamellas are present
In lamella, lacunas are present
In ~~te~~ one lacuna only a osteocyte is present.

* Cartilage
• Avascular in nature
• matrix: solid, soft, pliable (resist comparession)




• Cells:
(i) Chondrocyte ÷ mature cell
(present in lacuna)

(ii) Chondroblast ÷ chondrocyte forming cell

(iii) Chondroclast ÷ chondrocyte eating cell

* Types of cartilage

<1> Hyaline cartilage ÷ It is found in ribs, septum of nose, larynx and trachea.

<2> Fibrous ÷ It is found in intervertebral disc (the disc b/w vertebrae in the spine)

<3> Elastic cartilage ÷ It is found in tip of nose and ear pinna

<4> Calcified cartilage ÷ It is the hardest form of cartilage

* Fluild connective tissue

<1> Blood (red color liquid)

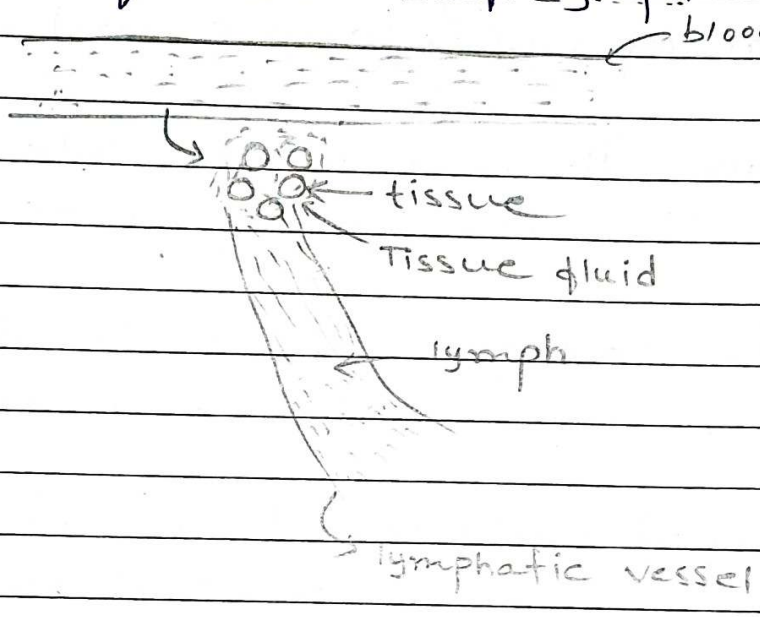
plasma (55%)
yellow color liquid

cellular part (45%)
cells are including RBC, WBC etc

<2> Lymph

- colorless liquid
- form lymphatic system
- no hemoglobin
- main function is to protect body from pathogen

formation of lymph




* Muscle tissue

origin: mesoderm

- Muscle is made of many long, cylindrical muscle fibres arranged in parallel array
- Each muscle fibres is made of myofibrils
- Muscle perform movement (contraction and relaxaction)

striated → appearance of muscle fibre under microscope

Myofibril
↓
muscle fibre
↓
muscle

- There are three types of muscle
(1) skeletal (2) Smooth (3) Cardiac

* Skeletal muscle tissue
- muscle is attatched to bone
- voluntary
- cylindrical
- multinucleated, unbranched
- striated (Strip present)
- location : biceps

* Smooth muscle tissue
- present in internal organs
- involuntary
- fusiform (end = narrow)
- unstriated
- uninucleated, unbranched

* Cardiac muscle
- present only in hurt
- involuntry
- straited
- branched, Intercalated disc is present

- ~~nn~~ uninucleated
- intercalated disc (gap junction)

* Neural tissue (two types)

<1> Neuron

- Detect, generate and contact nerve impulse

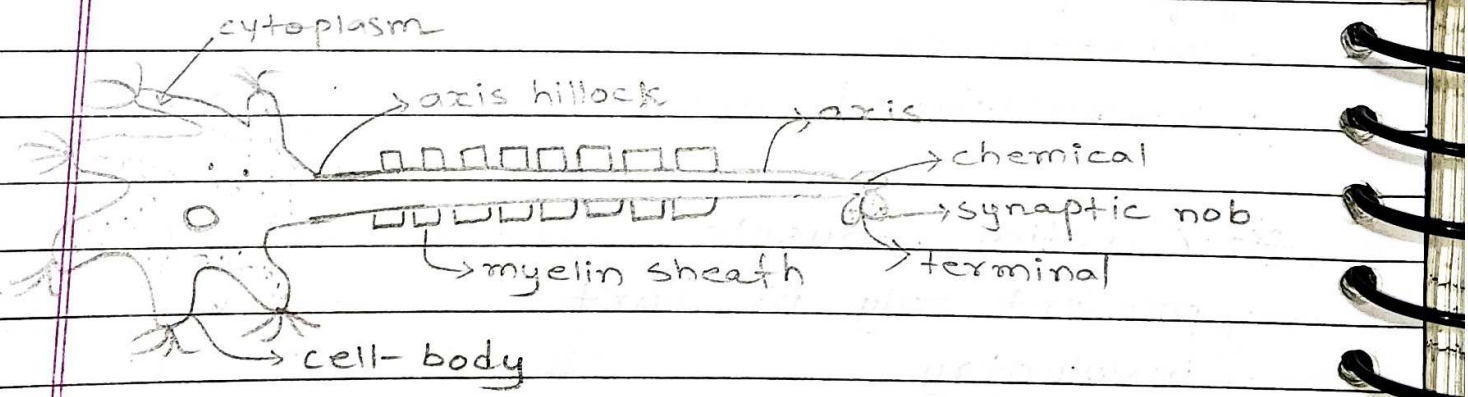
- Neuron has following parts

(i) Cell body / cyton / soma / perikaryon. cytoplasm nucleus, golgi body etc.

(ii) Dendrits (recieve signal)

(iii) Axon (single) (iv) Axon terminal

(iv) Synaptic know (swallen part, have chemical



(2) ~~Neo~~ Neuroglia

- Packaging tissue that is present around neuron.
- more than half volume of Neural tissue ~~nephron~~
- Neuroglia includes
  (i) Astrocytes ÷ formed BBB (blood brain barrier)
  (ii) Microglial ÷ phagocytic cell in brain
  (iii) Schwann cell ÷ form myelin sheath around the axons in PNS
  (iv) Oligodendrocyte ÷ form myelin sheath around the axon in CNS

* Cockroach

- "phylum ÷ Arthropoda"
- "class ÷ Insecta"
- "general colour ÷ brown, black"
- ~~tropical region~~ "size ÷ 1/4 – 3 inch (0.6 – 7.6 cm)"
- have long antenna, eyes, mouth, wings and legs
- Noctural (active in night), omnivore, cursorial (fast runner)

- "Cockroach (periplanta americana) size ÷ 34 – 53 mm (av. ~~adult~~)"

- "Wings of male extends to tip of abdomen"
- "Tropical region ÷ color is bright red, yellow and green".

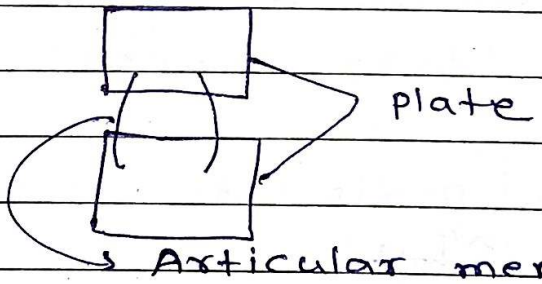
- Body is segmented
- Number of segment

| | | head | thorax | abdomen | Total |
|---|---|---|---|---|---|
| I | immature | 6 | 3 | 11 | 20 |
| | adult | 1 | 3 | 10 | 14 |

- Cockroach have exoskeleton (made of - chitin)
- Each segment is covered by plate called sclerite

- Sclerite
  Dorsal ÷ Tergite
  Ventral ÷ Sternite or sterna
  Lateral ÷ pleurite

- Two plates (sclerite) are joined by arthroidal membrane (articular membrane)
- Articular membrane is thin and flexible



fusiform → middle part is wider and both end is taper.

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- There are three parts of cockroach
(1) Head (2) Thorax (3) Abdomen

## * Head of cokroach

- Triangle in shape
- Have one pair compound eye, one simple eye (ocellus), one pair antenna (fusiform), one mouth (hypognathous) at 90° to body axis.

- Mouth is bitting and chewing type
- Head is formed by fusion of six segment
- mouth has ÷ labrum ÷ upper lip } unpaired
labium ÷ lower lip }

upper jaw or maxilla } paired
lower jaw or mandible }

hypopharynx ÷ tongue (1) → unpair

## * Thorax of cockroach

- Thorax has three segments:
(i) prothorax (ii) mesothorax (iii) metathorax

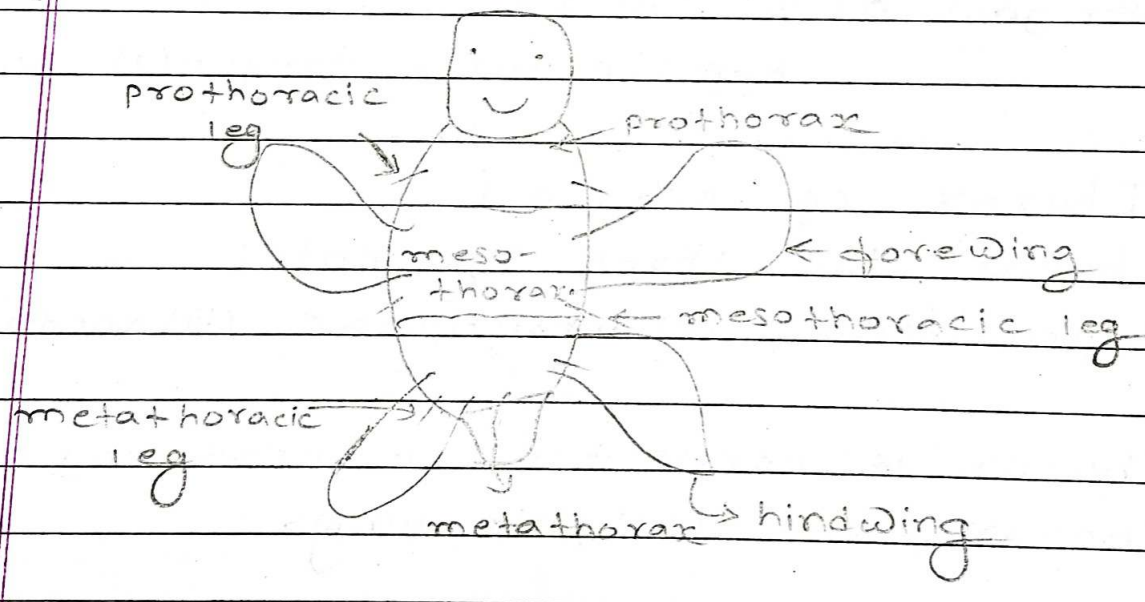
- Thorax is connected to head by neck
- Thorax has two pair wings

(i) 1st pair wings of mesothorax
(ii) 2nd pair wings of metathorax

(i) 1st pair wing of mesothorax
- forewing / mesothoracic / tegmina / elytra wing, dark opaque, not use in fly, cover and protect hindwing at rest

(ii) 2nd pair wings of metathorax
- Hindwing / metathoracic wing, use in flight, transparent, membranous, delicate (light)

- Thorax has three pair of legs one pair from each thoracic segment
(i) prothoracic leg (ii) mesothoracic leg (iii) metathoracic leg




(cockroach)

• male genital pore → opening of ejaculatory duct.

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* Abdomen of cockroach

• In abdomen 10 segments are present

| ♂ (male) cockroach | ♀ (female) cockroach |
|---|---|
| • gential chamber or gential pouch is formed by fusion of 9th and 10th (dorsally) and 9th sterna (ventral) | • gential chamber is formed by the fusion of 7th 8th and 9th sterna → boat-shape |
| • male of gential pouch contain<br>(a) dorsal → anus<br>(b) Ventral → male gential pore<br>(c) gonapophysics | • anterior portion of gential chamber contain<br>(a) collateral gland<br>(b) gonopore<br>(c) spermethecal pore |

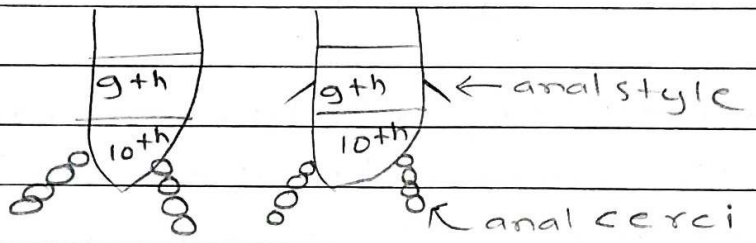
* Sexual dimorphosim in cockroach

Character by which male and female member can be distinguished externally on the basis of morphology

• Sexual dimorphosim is present in cockroach

• In male cockroach, one pair of anal style is present at 9th abdominal segment

. At 10th abdominal segment, pair of anal cerci is present in both male and female cockroach.




(a) ♀ (b) ♂

## * Digestive system of cockroach

. The alimentary canal of cockroach is divided into - foregut, midgut and hindgut

. Foregut includes - Mouth, pharynx (common - area of food and air), oesophagus / food pipe, crop (sac like, store food), gizzard / proventriculus (outer - thick, circular - muscle, inner - thick chitineous plate)

. Foregut is lined by cuticle
. Gizzard help in grinding of food.

. At the junction of foregut and midgut 6-8 blind tubules are present which are called hepatic or gastric caeca (it secrete digestive enzyme in midgut)

- Maximum digestion take place in midgut/ mesenteron
- There are no cuticle in midgut
- At the junction of midgut and hindgut, 100-150 yellow, thin filamentous malphigian tubules are present
- Malphigian tubules helps in removal of waste from haemolymph
- Hindgut divided into three regions - ileum, colon and rectum.
- Undigested food is excreted out by anus through the rectum.

* Digestive enzyme of cockroach

| Salivary gland (one pair) | Hepatic caeca |
| --- | --- |
| • provide saliva<br>• Salivary reserviour | • 6-8 blind tube<br>• blind tube open at one side only b/w foregut and midgut<br><br>• blind tube → tube that has only one opening. |

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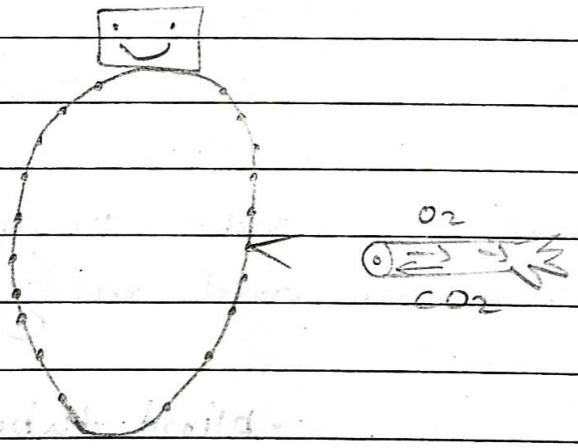
* Respiratory system of cockroach

- Cockroach have 10 pair/20 spiracles (opening) at the lateral side ~~of kidney~~
- Spiracles open into trachea/tracheal ~~tube~~ which is subdivided into tracheoles which ~~form~~ a network

air from environments
↓
spiracle
↓
trachea
↓
trachole $\rightleftharpoons$ tissue
($O_2$ / $CO_2$)
↳ diffusion

- Spiracle is regulated by spincter
- 10 pair ~~sh~~ spincter are present



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* Blood circulatory system of cockroach

There are two types of blood circulatory system in animals

(i) Open blood circulatory system
- Blood vessels are poorly develope
- Visceral organ directly bathed in haemolymph
ex: cockroach

(ii) Closed blood circulatory system
- Blood vessels are well develope
- Blood flow in proper blood vessels
ex: human

- Cockroach have open blood circulatory system, blood opens into cavity called haemo.
- Vesceral organs are directly bathed into haemolymph

haemolymph → plasma
haemolymph → haemocyte/cells

- Heart in cockroach is 13 chambered which is situated at mid dorsal line of thorax and abdomen.

• 1st chamber of cockroach heart has no ostia and allary muscle.

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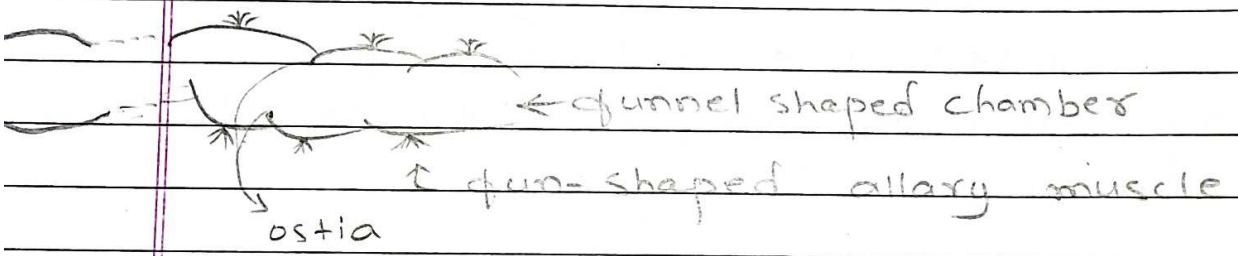
• Shape of chamber ÷ funnel shaped

• 12 pair of ostia are present in hurt of cockroach.

• 12 pair fan-shaped allary muscle are present in heart that helps in contrac-tion of heart.

• In the heart of cockroach, blood is pumbed anteriorly




* Excretory system of cockroach

• Cockroach is uricotelic (it's excrete uric-acid)

• $N_2$ waste removed by organ → malphigian tubule

• Malphigian tubule ÷ 100-150, at the junction of midgut and hindgut, yellow, thin and filamentous.

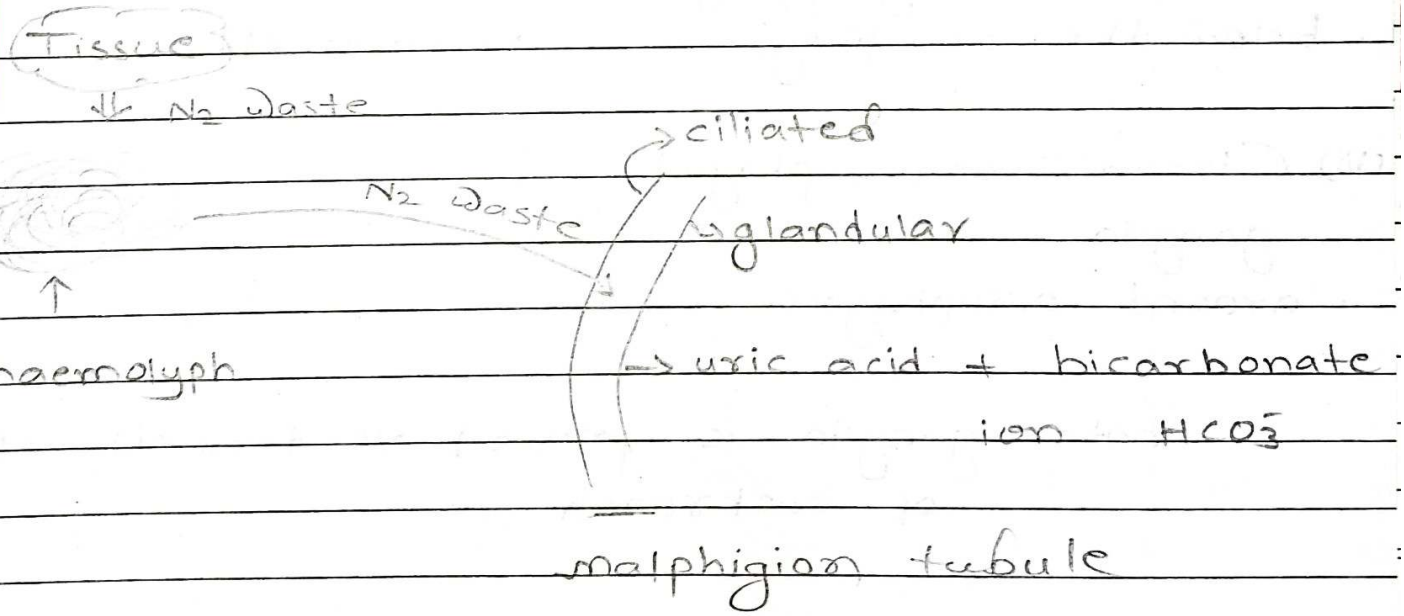
- Tissue of cockroach, release $N_2$ waste in the form of potassium urate

- Potassium urate dissolve in haemolymph. ~~form~~ from haemolymph malphigian tubule absorb $N_2$ waste in the form of uric acid

- Malphigion tubules is lined by two types of cell :-

(i) Glandular cell :-

- Convert potassium urate into uric acid. $HCO_3^-$, uric acid excreted through hindgut



(iii) Ciliated cells

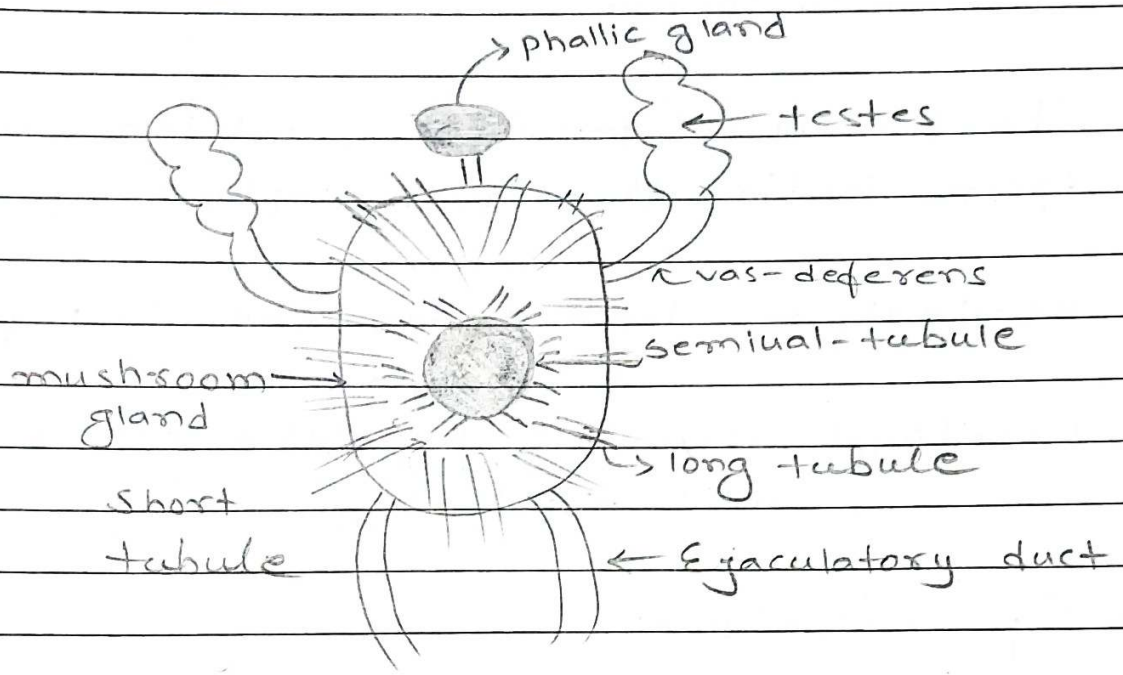
These cells are responsible for moving waste products from haemolyph into the tubule. The cilia help in movement of the contents within the tubule, facilitating the excretion process.

* Nervous system of cockroach

| In head | In abdomen and thorax |
| --- | --- |
| There are three ganglia | · 9 fused ganglia in the form of nerve cord |
| (i) Supra-oesophagal ganglia<br>· above oesophagus<br>· brain of cockroach<br>Supplies nerves to antenna and compound eye | · 3 ganglia in thorax and 6 in abdomen |
| (ii) Sub-oesophagal ganglia<br>below the oesophagus | · Nerve cord is solid, double, situated in ventral side |
| (iii) Circum oesophagal-ganglia<br>around oesophagus | |

note:- ganglia is present ventral side of body of cockroach.

R * Male reproductive system of cockroach




<1> Testes (one pair)

- Lobed structure: each testes has 3–4 lobs
- Location: found b/w the 4th and 6th abdominal segments
- Function: sperm formation takes place in testes

<2> Vas deferens

- Thin tubules that carry sperm from the testes to mushroom gland.

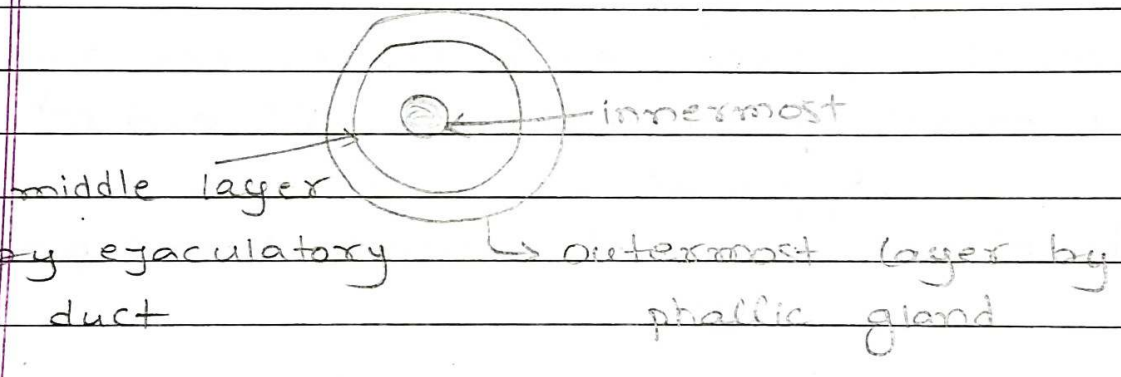
<3> Mashroom glands

- long tubule: responsible for gluing sperm together and forming the innermost

layer of spermatophore (a packet or capsule - that hold sperms)

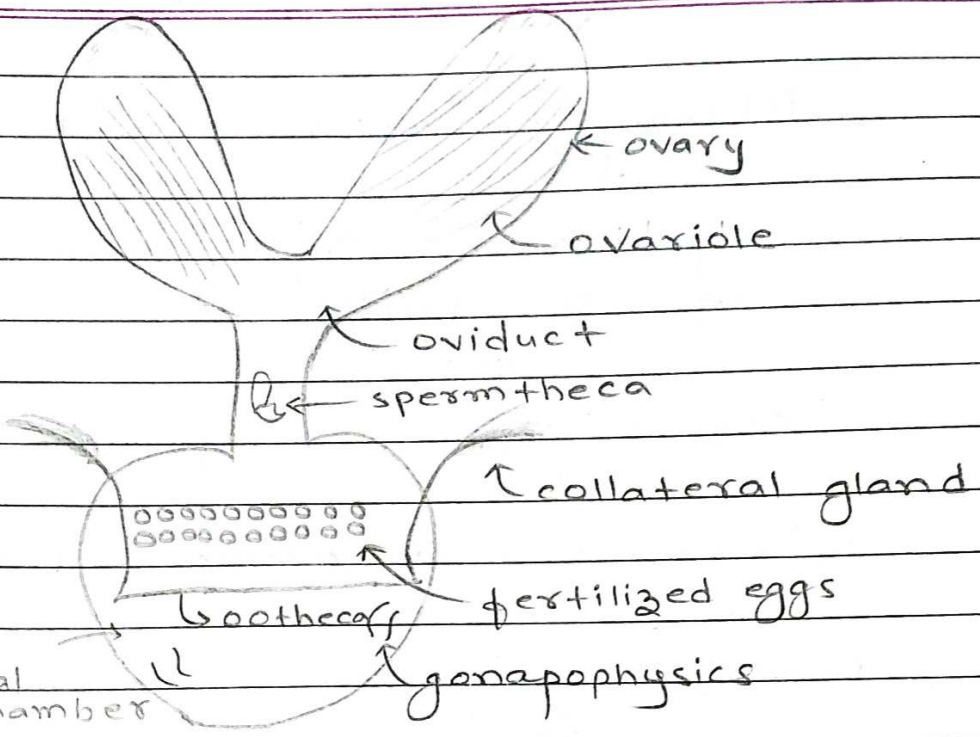
- Short tubules: provide nutrition to sperm inside the spermatophore
- Seminal vesicles ÷ Store the 1-layered spermatophore
- Location: situated b/w the 6th and 7th abdominal segments

<4> Spermatophore:




- 1st layer formed by the long tubules of mushroom gland
- 2nd layer formed by the ejaculatory duct during capulation.
- 3rd layer formed by the pallic gland located above the mashroom gland.

R * Female reproductive system of cockroach




- One pair of large ovaries, lying laterally b/w 2nd and 6th abdominal segment.

- each ovary has 8 ovariole/ovarian tube which have chain of developing ova. from each ovary oviduct arise and both oviducts join to form common oviduct/vagina.

- At anterior region of genital chamber three things open
  (i) vagina/common oviduct
  (ii) pair of spermtheca
  (iii) pair of collaterial gland.

- Collateral gland form ootheca./ case of ootheca

- Spertheca store sperm in female body

- After copulation
  ↓
  ~~Sperm~~ spermatophore tranferred in ♀ body
  ↓
  Sperm store in spermtheca
  ↓
  16 ovas from 16 ovaries and sperm ↑ fertilize
  ↓
  Fertilized eggs are store in ootheca (14-16 eggs)
  ↓
  Ootheca is released outside with the help of gonapophysis/chitineous plate
- Fertilization is internal in cockroach
- Development → Indirect development
  ↳ larva = nymph
- Paurametabolous development
- ootheca → nymph → → adult
  ↳ 13 times mouting
- Nymph has no winge

Note :- (i) 6th segment = collateral gland

(ii) Ootheca is dark red-brown in color (size - 3/8 inch)

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# * Sense organ of cockroach

(1) Antenna (1 pair)

- Detect chemicals, temperature changes and physical contact

(2) Compound eye (1 pair)

- Ommatidia ÷ about 2000 units
- Adapted for night (noctural vision)
- Seen in a mosaic pattern
- Sensitive to movement, but low resolution

(3) Anal cerci (one pair)

- Deetects air movements and vibrations helping sense threats.

(4) Maxillary palp and labial palp

# * Frog

- class ÷ Omphibia (can live on both water & land)
- phylum ÷ chordata
- Body is divided into head and trunk (fused thorax and abdomen)
- no neck, no tail
- 2 pair of limb is present in frog
  - one pair forelimb
    - ↳ 4 digits
  - one pair hindlimb
    - ↳ 5 digits
- colour of frog
  - → Dorsal ÷ olive green with irregular spot
  - → Ventral ÷ pale yellow with no spot
- Most common species of frog is found in India → Rana tigrina
- Cold blooded (pokilotherm) animal
  - → can't maintain constant body temperature
  - → Change body temperature a/c to environment

ex: frog

- Warm blooded (homeotherm) animal
→ Can maintain constant body temperature
ex: human

- frog is cold blooded

- frog has the ability to change its color (camouflage property) to protect itself from enemy. It is a type of protective mimicry.

- During extreme cold and hot weather condition, frog get in deep burrows. This is known as winter or summer sleep
- Summer sleep (Aestivation) → During high temperature
- Winter sleep (Hibernation) → During low temperature

- Head has mouth, above the mouth one pair nostril is present

- One pair of bulged eye present (with nictating membrane)

- Nictating membrane covers eyes and protect it in water

- One pair tympanum membrane is present that recieve sound signal.
- Skin of frog is slippery and moist due to presence of mucus.
- Skin is maintained in moist condition
- Forelimb and hindlimb help in walking, jumping, swimming etc
- Sexual dimorphism is present in frog.
- ♂(male) frog
→ Vocal sac (sound production)
→ Copulatory pad/nupital pad on 1st digit of forelimb

## * Digestive system of frog

Alimentary canal of frog is short because frog is a carnivore.

food captured by biolobed tongue
↓
Buccal cavity
↓
pharynx
↓

oesophagus / food pipe
↓
stomach
Wall of stomach secrete HCl and gastric juice, here digestion of food start partially digestive food which is acidic in nature is called chyme.
chyme from stomach
↓
Duodenum, ileum } intestine
↳ common bile duct

- In intestine final digestion will take place.
- Common bile duct is common duct for bile and and pancreatic juice
- Liver secretes bile but it is stored in gall bladder.

* Respiratory system of frog

- On land

(a) Through moist skin by simple diffusion (cutaneous respiration).

(b) Through buccal cavity exchange of gas
→ through simple diffusion.
(Buclopharyngeal respiration)

(c) Through lungs → frog have small lunge, and they breathe using positive pressure.

- In tadpole, respiration is done by gills (branchial respiration)
- In aestivation and hiberation, respiration is done by skin.

## * Circulatory system of frog

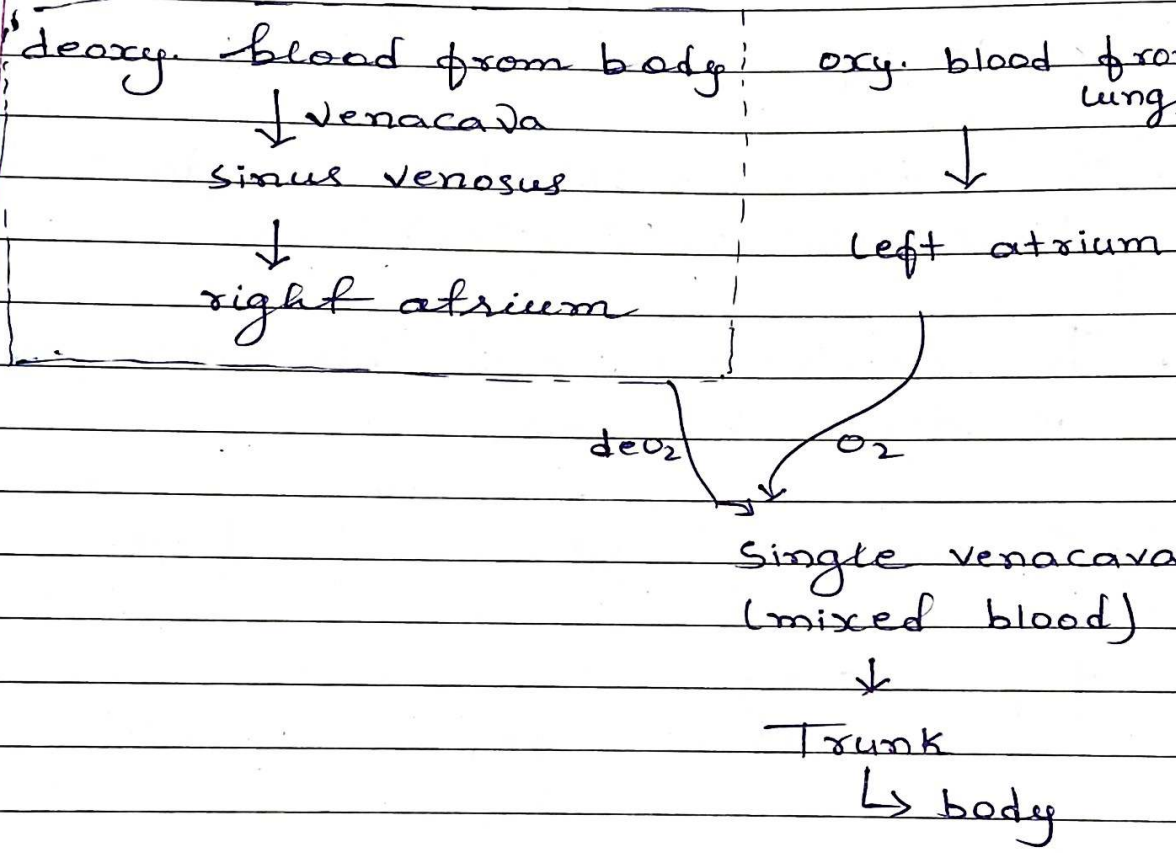
- frog has :-

Blood vesscular system
→ have blood, blood vessels and heart

Lymphatic system
→ have lymph, lymph-cannel, lymph nodes

- Blood vesscular system of frog is Well-~~devo~~-developed and 'close type.

- Heart of frog is three chambered (two atria and one ventricle) two additional chambers also present (i) sinus venosus (ii) conus arteriosus (sac-like, ventricle)




* Blood circulation in frog

deO2 blood from body get collected in sinus venosus through venacava

from S.V deO2 blood enters right atrium

Right atrium
↓
from right atrium deO₂ blood enters in ventricle

from lungs, O₂ blood enters in ventricle

↓

In single ventricle, O₂ and deO₂ blood get mixed

↓

mixed blood get collected in conus arteriosus

↓

mixed blood is supplied to the body through aorta

Note: Heart of frog is covered by double membrane pericardium

- Blood
  - plasma
  - Cells
    - RBC → Nucleated, have haemoglobin
    - WBC
    - platelet or thrombocyte

- Lymph ÷ no RBC, have WBC, colorless few protein.

- Frog have two portal system

(1) Hapatic portal system
→ b/w intestine and liver

(2) Renal portal system
→ b/w lower part of body and kidney.

* Excretory system of frog

- Frog excrete urea, so it's ureotelic

- Excretory system of frog consist of ÷
(i) one pair kidney
→ dark red color, bean shaped in posterior portion.

(ii) One pair ureter (iii) one cloaca
(iv) one urinary bladder.

- Structural and functional unit of kidney is nephron or uriniferous tubule

- Urine formed in kidney, gets into ureter with open into cloaca

- Urinary bladder is thin walled present ventral to rectum, function is to store urine

- Cloaca is common chamber where these things open + ureter, rectum, urinary-bladder, oviduct (♀ frog)

| ♂ frog | ♀ frog |
|---|---|
| • ureter carries both urine and sperm, so it is called as urino-genital duct | • ureter carry only urine<br>• oviduct carry ova<br>• No urinogenital duct is genital duct here. |

Note: • tadpole frog is ammonotelic
- Adrenal gland is present inside the Kidney.
- Fat body is present above the kidney.

* Control and coordination in frog

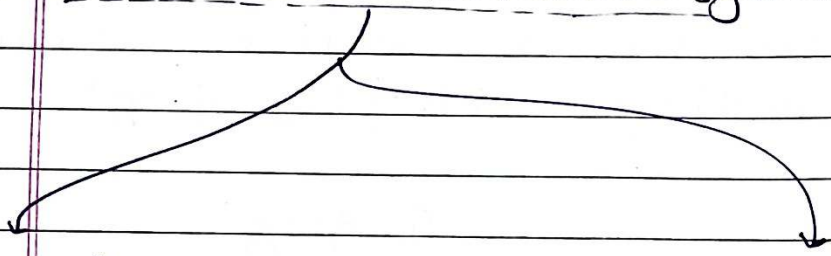
- In frog control and coordination is done by two system

(1) Nervous system (2) Endocrine system

* Nervous system of frog (three types)

(1) Autonomic (2) peripheral (3) Central

* Autonomic nervous system of frog



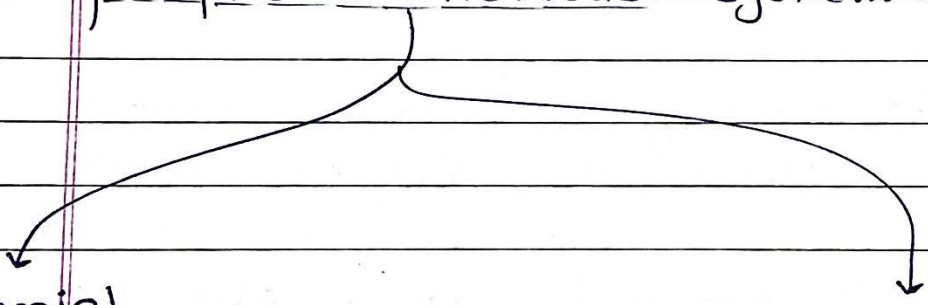
Sympathatic nervous system

→ Work during emergency

parasympathatic nervous system

→ Work during rest

* Peripheral nervous system of frog



Cranial ervous system

nerve form brain (10 pair)

Spinal nervous system

→ nerve form spinal cord

* Central nervous system of frog (two types)

<1> Brain
→ enclosed in a box called cranium / brain box.

• Brain of frog is divided into three parts

(a) forebrain
→ paired cerebral hemisphere
→ unpaired diencephalon
→ olfactory lobe

(b) Midbrain
→ pair optic lobe (corpora bigemina)

(c) Hindbrain
→ cerebellum
→ medulla oblangata

<2> Spinal cord
→ spinal cord is enclosed in vertebral column
→ Medulla oblongata continus as spinal cord after entering foramen magnum.

## * Endocrine system of frog

- Includes endocrine gland which release hormones
- pituitary gland
- Thyroid "
- parathyroid "
- Thymus "
- pineal "
- pancreas "
- Adrenal "
- Gonads "

## * Sense organ of frog

- touch → sensory papillae
- smell → olfactory epithelium
- vision → simple eye (one pair) in orbit of skull
- taste → taste buds
- hear → tympanum + internal ear

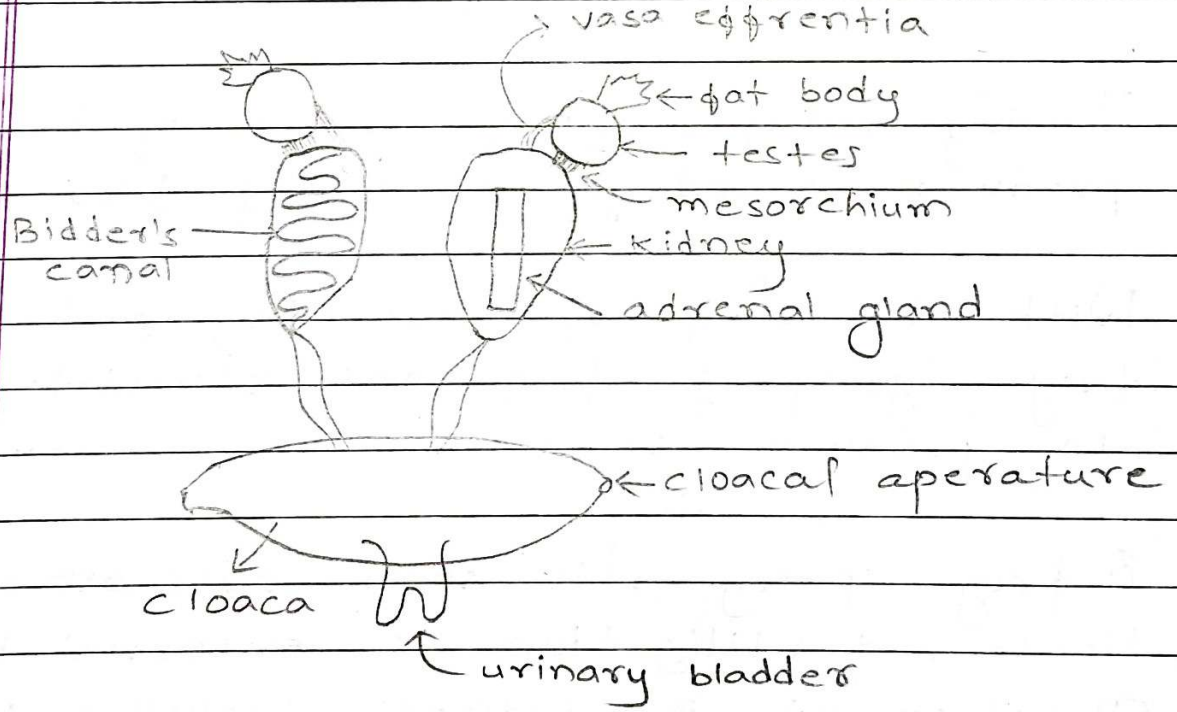
→ External ear is absent in frog ear has two work (~~of~~ frog) → hearing and balancing

## * Male reproductive system of frog

- Consist of :
  (i) pair of ovoid yellowish testes (formation of sperm)
  (ii) 10-12 vasa efferentia (carry sperm from testa)
  (iii) Bidder's canal (inside kidney)
  (iv) Urinogenital duct (carry both urine and sperm)
  (v) cloaca

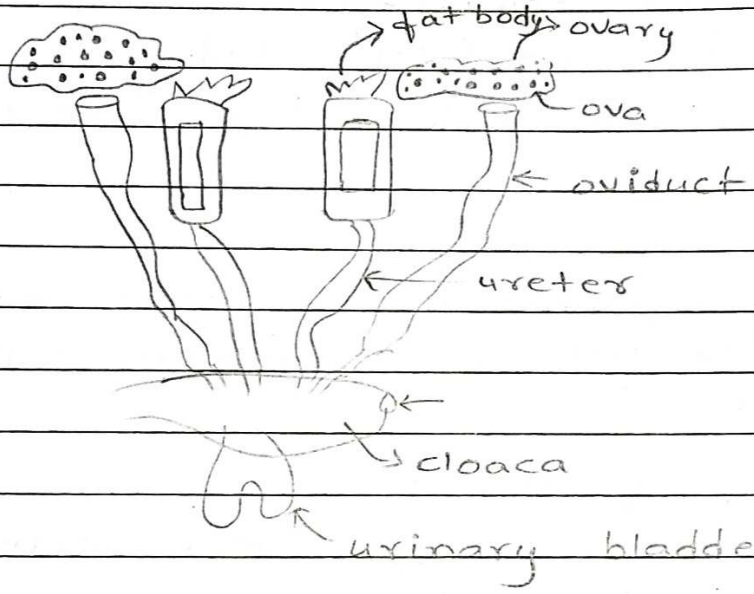
- Testes is adhered to upper part of kidney by double fold of peritoneum called Mesorchium

- pathway of sperm :
  Testes → vasa efferentia → kidney → Bidder's canal → urinogenital duct → cloaca → outside



## * Female reproductive system of frog

- One pair of ovaries (near kidney)
- One pair oviduct arise from ovary
- Oviduct opens into cloaca




## * Reproduction in frog

During rainy season, vocal sac of ♂ frog produce sound to attract ♀ frog

↓

With the help of copulatory pad ♂ frog grasp ♀ frog and stimulate her to produce ova (2500 – 3000 ova/time)

↓

♂ frog spray his sperm over ova in water
Hence, fertilization is external, in water
Development is indirect including larval stage called tadpole

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tadpole undergoes metamorphosis to become adult

* Benifits of frog

(i) frog eat insects and protect our crops
(ii) play important role in food chain and food web
(iii) eaten as food also, in some part of world

Note :- . There is structural and function connection b/w kidney and testes, ~~sperm~~ but this is not true for ovary and kidney

- For ~~metap~~ metamorphosis in frog; Iodine play very important role.

7

- Our heart consist of all four types of tissue.
- Fibres are present in adipose, areolar, bone cartilage, (except blood).

# Biomolecule

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## * Introduction

- Chemical analysis on animal tissue, plant tissue or microbial paste give a list of elements.

- When we do chemical analysis on earth's crust We get same list of elements but their concentration is different in both living tissue and non-living earth's crust

- Elements like carbon, hydrogen, nitrogen, oxygens, sulpher are more in living animal tissue. While few elements like sodium calcium, magnisam and silicon are more in earth's crust

- To know the cellular compositions ~~scientists~~ scientists perform two experiments (i) Chemical analysis (ii) Elements analysis

## * Experiment - 1 (Chemical analysis)

- To know the organic component of the cell

- Flow chart of this experiment is ~~bew~~ below

↓

piece of live/fresh vegetable

↓

Grinded in mortar and pastle using TCA (trichloraceti-acid)

↓

Strain the thick slurry/paste using muslin and cloth or cheese cloth

↓

Two particle found

(i) Acid soluble (ii) Acid-insoluble

* Acid soluble pole (ASP) or Biomicro molecule or filtrate

- Includes ÷ Monomer
- molecular Weight ÷ 18 - 800 Dalton or less than 1000 Dalton
- Includes ÷ monosaccharide, amino acid, ions, nucleoside, nucleotide

* Acid-insoluble pool (AIP) or Biomarco molecule or retentate.

- Includes ÷ polymer
- Molecular Weight ÷ 10,000 Dalton
- Includes ÷ protein, lipids, polysaccharide

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- Lipid is exception of AIP, it has 18-800 Dalton molecular weight but still remain in acid insoluble pole due to formation of aggregation.

- Cell membrane has lipids, when cell is broken, lipid in cell-membrane formed aggregation.

* Experiment - 2 (Element analysis)

- Destruction in nature
- For study of inorganic component
- Flow chart of this experiment

fresh leaf
↓
dry in oven (have $H_2O$ + organic + inorganic)
↓
dry leaf (dry weight)
↓ burn
ash (have inorganic protein only)

* Biomolecule

→ All organic compound that we get from living tissue is known as biomolecule

Water ÷ 70-90%

protein ÷ 10-15%

Carbohydrate ÷ 3%, nucleic acid ÷ 5-7%

lipid ÷ 2%, ions ÷ 1%

Note: Most abundant chemical in our body ÷ Water

Most abundant biomolecule in our body ÷ protein

* Metabolism and Metabolites

. Overall reactions taking place in our body is called metabolism

. Compound that participate in metabolism are called metabolites

• Metabolism (two types)

(1) Catabolism
→ breakdown of substance
→ Energy ~~requir~~ release
→ ex: breakdown of ~~gly~~ glucose

(2) Anabolism
→ Formation of compound
→ Energy require
ex: formation of glucose

- Metabolites (two types)

(1) Primary metabolites
- Found in all living organism
- Have known role
- Play important role in our body.

ex: protein, carbohydrate, lipid etc

(2) Secondary metabolites
- Found in microbe, plant and fungi
- Play unidentified role

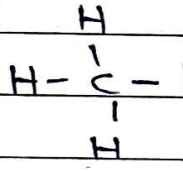
ex: rubber, oil
- Secondary metabolites used in welfare for human, or play important role for ecology.

* Some secondary metabolites

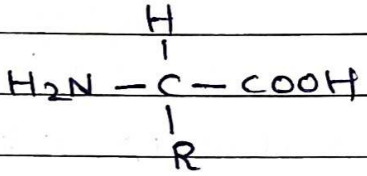
| | |
|---|---|
| pigments | Carotenoids, Authocyanins |
| Alkaloids | Morphine, codrine |
| Terpenoids | Monoterpenes, diterpenes |
| Essential oil | lemon grass oil |
| Toxins | Abrin, ricin |
| Lectins | Concanavalin A |
| Drugs | Viblastin, Curcumin |
| polymeric substance | rubber, gums, cellulose |

* Amino acid

- Monomer of protein
- Found in acid soluble pool
- MW = 18 – 800 Dalton
- 20 types of amino acid form protein in nature. These amino acid are called standard amino acid.
- Amino acid is substituted methane
-



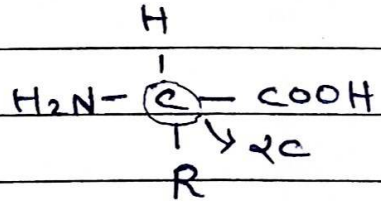
methane



- Amino-acid have four groups
  (i) hydrogen → constant
  (ii) Amino ($NH_2$) → constant
  (iii) Carboxylic acid (COOH) → constant
  (iv) Alkyl group → variable

- Amino acid is also called as α-amino acid, because it has αC

- α carbon is that carbon which has both functional group ($NH_2$ and COOH)



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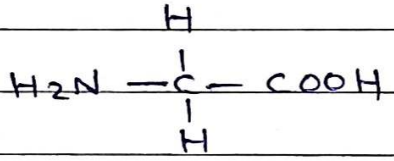
- Chiral carbon
→ Carbon having all sides different
→ optically active in nature

- Achiral carbon
→ When carbon has similar group as valency
→ optically inactive.

* Glycine
- Simplest amino acid
- R ⇒ H, in glycine
- optically inactive amino-acid



* Types of amino acid
→ On the basis of acidic and basic group amino acid is of three types.

(1) Acidic amino acid
- $COOH > NH_3$

ex: glutamate, asportate

(2) Basic amino acid

- $NH_3 > COOH$

ex: histidine, orginine, lysine

(3) Neutral amino acid

$NH_3 = COOH$

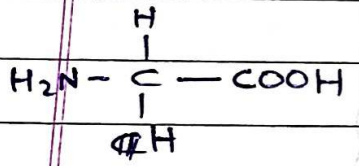
ex: glycine, alanine, serine

Note: Extra $COOH/NH_3$ is present in R group

* Structure of amino acid

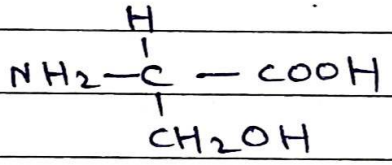
Glycine

$R = H$



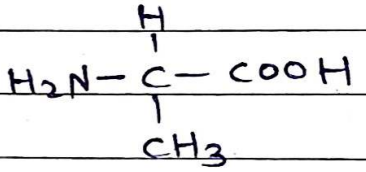
Serine

$R = CH_2OH$



alanine

$R = CH_3$ (methyl)



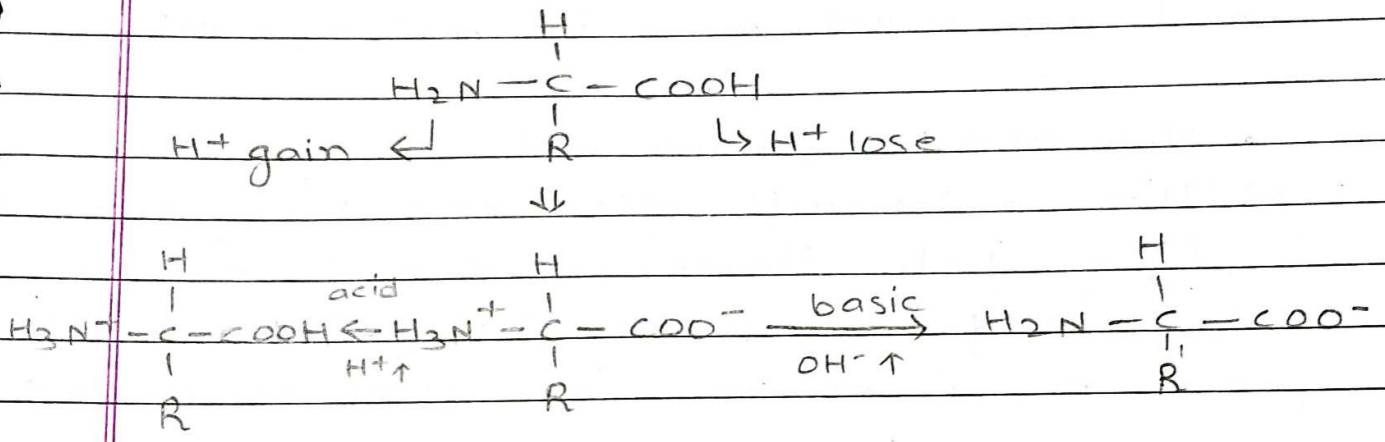
Note:

- Basic amino acid is called +ve charged amino acid
- Acidic amino acid is called -ve charged amino acid.

* Zwitter ion

- Ions which has both +ve and -ve charge is known as zwitter ion.

- Zwitter ion exists at isoelectric pH




*

- Aromatic amino acid

→ R group is ring like

ex: Tyrosine, Tryptophan, phenylalanine

- Sulfar containing amino acid

ex: cysteine, methionine

- OH containing amino acid

ex: serine

## * Essential and non-essential amino acid

• Essential amino acid

→ Those amino acid which are not synthesised by our body. Hence, it is essential to take them from our diet. Those amino acid are called essential amino acid.

• Non-essential amino acid

→ Those amino acid which can be synthesised by our body. Hence we doesn't require them from our diet. These amino acid are known as non-essential amino-acid

## * Semi-essential amino acid

→ The production of those amino acid is very slow in our body. Due to which, in case of emergency, they are essential for our body these amino acid is known as semi-essential amino acid.

Note: The chemical and physical properties of amino acid are essentially of amino, carboxyl and R functional group

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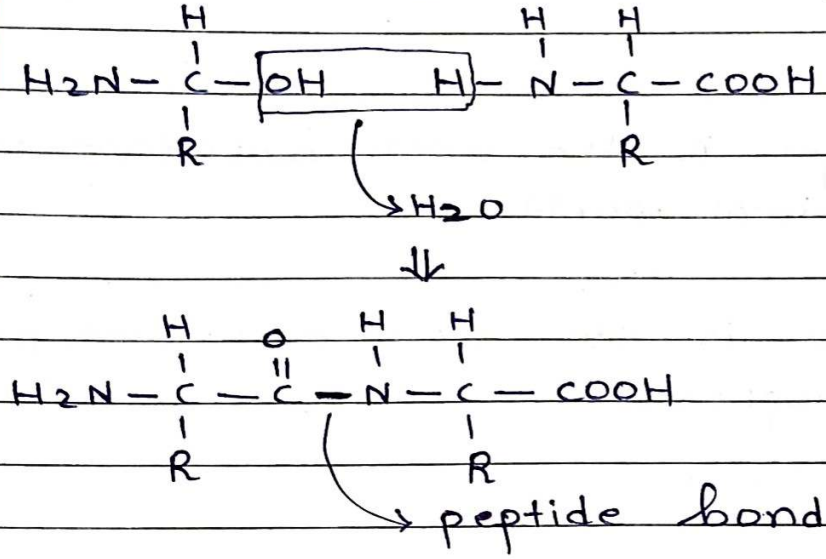
## * protein

- protein is found in biomacromolecule
- protein is hectropolymer (made of different types of amino-acid)
- amino acid polymerise to form protein




- peptide bound is also known as dehydration bound or amide bound.

- Number of $H_2O$ removed/peptide bound in linear sequence = total no. of amino acid - 1

- There are two types of polypetide chain
  - N-terminal ($NH_2$ is found)
  - C-terminal (COOH is found)

• protein performs diverse function for example :-

hormones → insulin
transporter → ~~blue IV~~ Glut-IV
intercellular matrix → collagen

note:

• collagen is the most abundant protein in animal world.

• Rubisco is the most abundant protein in biosphere

* Some protein and their function

(1) collagen → intercellular ground substance

(2) Trypsin → Enzyme

(3) Insulin → hormone

(4) Antibody → fight infection agents

(5) Receptor → sensory reception (smell, taste etc)

(6) GLUT-4 → Enable glucose transport into cell.

- 1st amino acid in protein chain is present at left end, called N-terminal amino acid.

- last amino acid in protein chain is present at right end, called C-terminal amino-acid.

$a_1 - a_2 - a_3 - a_4$

↳ C-terminal amino acid

↳ N-terminal amino acid.

## * Structure of protein (Four types)

### (1) primary structure

- amino acid joined linearly by peptide bound.
- Only peptide bound is present
- Gives positional information about amino acid

N ——— C

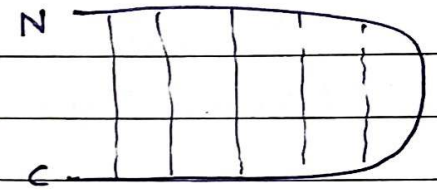
1° structure

### (2) Secondary structure

- Secondary structure is folded into 2° structu-re
- peptide bound + H-bound is present.

• In secondary structure, 2 forms are present

- α-helix
  - Right handed → ound in human
  - left handed → absent in human
- β-pleated sheet
  - parallel
  - anti-parallel




(3) Tertiary structure

• futher folding of secondary structure give rise to tertiary structure.

• peptide bound + H- bound + other bound like ions bound, vanderwal force etc are present

• give 3-dimensional structure of protein

- It is like a hallow woolen ball
- Biological activity of protein is present at tertiary structure

ex:- myoglobin

(4) Quanternary structure

- When more than one subunits are involved in protein or polypeptide.

ex:- haemoglobin

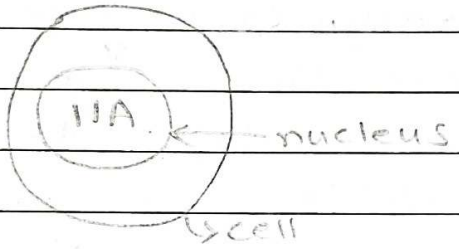
- Structure of haemoglobin

4 chains

2α chain  2β chain

for adult haemoglobin

* Nucleic acid
- found in acid - insoluble pool
- polymer of nucleotide
- In cell, it is found in nucleus and it is acidic in nature. hence, it is named as nucleic acid.
- It is -ve charged due to presence of phosphate / phosphoric acid




- It includes DNA and RNA

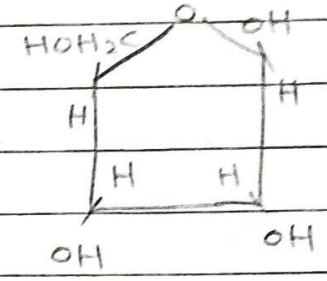
- In nucleotide 3 components
(i) sugar (ii) Nitrogenous waste (iii) phosphate

- In nucleoside two components
(i) sugar (ii) Nitrogenous waste

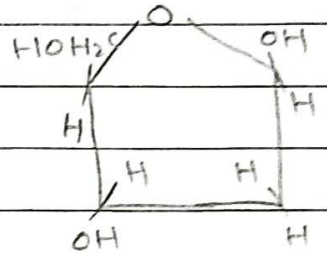
Note :- Nucleoside + phosphate = Nucleotide

* Sugar
- pentose sugar (5c)
- two types

(i) Ribose
- found in RNA

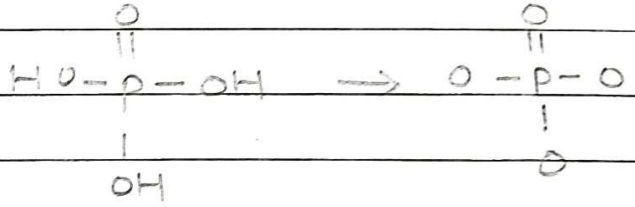



(ii) Deoxyribose
- found in DNA




note:- When we remove oxygen at 2'c of ribose then deoxyribose is formed

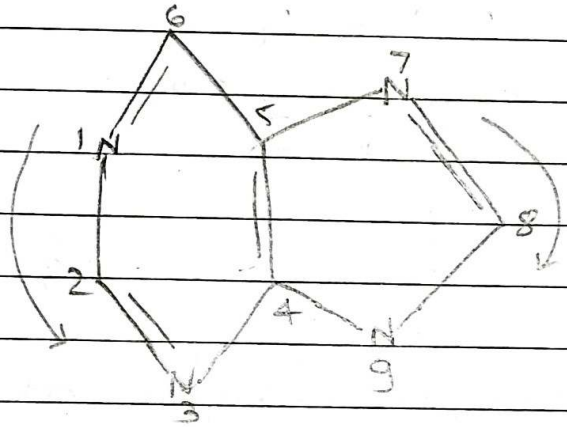
* phosphate
- also known as phosphoric acid
- give -ve charge to nucleoic acid/DNA



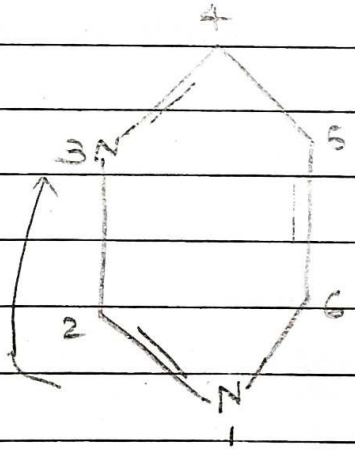
* Nitrogenous base

- Hectrocyclic ring
- two types

(i) purine
- 2 fused ring, 9 membered ring




(ii) pyrimidine
one ring, 6 membered ring



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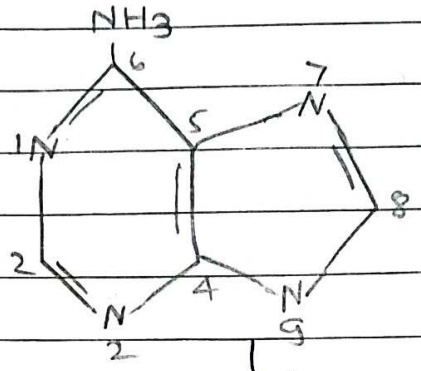
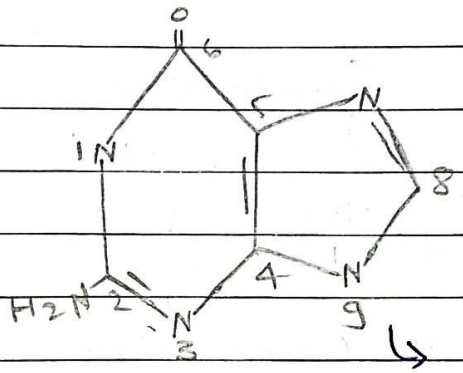
* Purine

(i) Adenine




↳ 6-amino purine

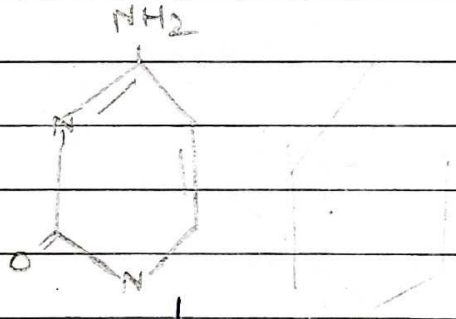
(ii) Guanine




↳ 6 oxy, 2-amino purine

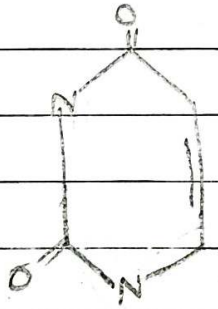
* Pyrimidine

(i) Cytosine




↳ 2-oxy, 4-amino pyrimidine

(ii) Uracil

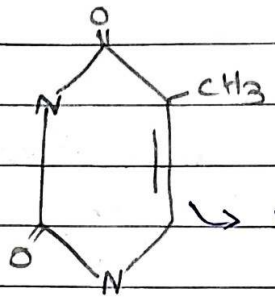



↳ 2-oxy, 4-oxy pyrimidine

or,

2,4 dioxy pyrimidine

(iii) Thymine




↳ 5-methyl, 2,4 dioxy ~~pyrm~~ pyrimidine

*

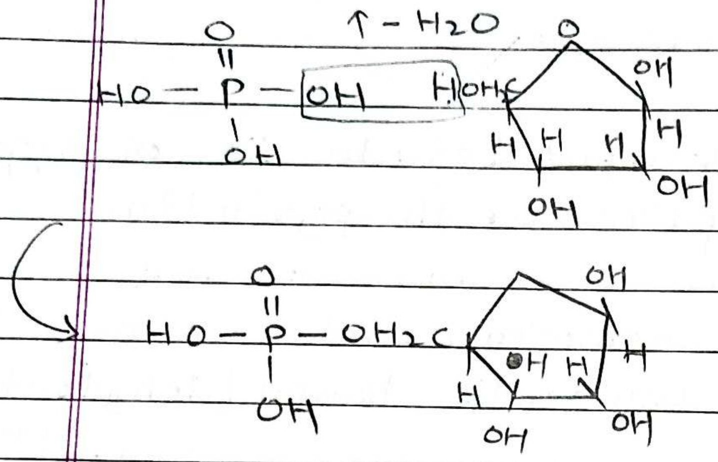
| N-base | Nucleoside | Nucleotide |
|---|---|---|
| Adenine | Adenosine | Adenylic acid |
| Guanine | Guanosine | Guanylic acid |
| Cytosine | Cytidine | Cytidylic acid |
| Uracil | Uridine | Uridylic acid |
| Thymine | Thymidine | Thymidylic acid |

## * Formation of nucleoside

- Always, N- base is attatched to 1'c of sugar through $N_9$ of prine or $N_1$ pyrimidine
- $H_2O$ molecule is removed, and a new bound form known as glycosidic bound (dehydration - bound)
- As N atom is involves in making glycosidic bound, this glycosidic bound known as N-glycosidic bound.

## * formation of nucleotide

- When phosphate is added to nucleoside then nucleotide is formed.
- phosphate is added to 5'c of sugar
- Name of bound formed b/w sugar and phosphate is known as ester or phosphoester bound. $H_2O$ is removed during bound formation.





* formation of nucleic acid

- Nucleic acid is formed by polymerizing nucleotide

- 3' OH of 1st nucleotide and 5' p of 2nd nucleotide participate in bound.

- The name of bound that is formed b/w two nucleotide is phospodiester bound.

- It is said ~~to~~ phosphodiester bound because two ester bound are formed. 1st b/w phosphate and nucleotide and 2nd b/w two nucleotide.

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* ~~Wato~~ Watson crick model

- Given by Watson and crick scientist
- Explain secondary structure of DNA
- In human body B form of DNA is formed
- DNA is double stranded ~~standared~~ and helical
- Both strand run antiparallel to each other
- The backbone of strand is formed by the phosphate sugar
- N- base projected perpendicularly ~~toward~~ to inside facing each other.
- A, T, G, C ÷ N- base found in DNA
  A, U, G, C ÷ N- base found in RNA
- Always A and G of strand compulsarily bind with T and C respectively
- 2H- bound ( hydrogen bound ) formed b/w A and T (A=T), and 3H- bound formed b/w G and C (G≡C)

- One turn of DNA includes = 10 base pair, per base pair helical rise 36°/turn, pith (length of turn) = ~~36Å~~ 34 Å

Distance b/w base pair = $\frac{34\text{ Å}}{10} = 3.4\text{ Å}$

## ✱ Lipid

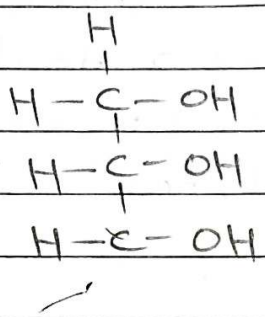
- lipid is oily, greasy in nature
- found in acid - insoluble pool
- Its molecular weight is in b/w 18-800 Dalton. ∴ But due to aggregation it is found in acid - insoluble fraction that's the reason we call it false macromolecule

- There are three types of lipid
(1) Simple lipid
(2) Conyugated lipid
(3) Derived lipid

## ✱ Simple lipid

- lipid with simple structure includes
(1) Glycerol
(2) Fatty acid
(3) Glyceride

(1) Glycerol ÷ Trihydroxy propane



(2) Fatty acid

- long chain of hydrocarbon with COOH at terminal (end).
- have one to 19C in hydrocarbon
- $C_1 - C_2 - C_3 ---$ C(=O)–OH
- There are two types of fatty acid
- (i) saturated (ii) ~~unsat~~ unsaturated

(i) Saturated fatty acid

- only single bound is present in hydrocarbon chain.
- difficult to digest

ex÷ ghee butter

- palmiti acid (16C) → $CH_3(CH_2)_{14}COOH$
- Stearic acid (18C) → $CH_3(CH_2)_{16}COOH$
- arachidic acid (20C) → $CH_3(CH_2)_{18}COOH$

(ii) Unsaturated fatty acid

- Double and triple bound are present
- low melting point
- easy to digest

ex÷ gingelly oil
oleic acid (18C) → 1 double bound
linolic acid (18C) → 2 double bound
linolenic acid (18C) → 3 double bound
arachidonic acid (20C)

note÷
- MUFA = mono ~~us~~ unsaturated fatty acid, only double bound is present

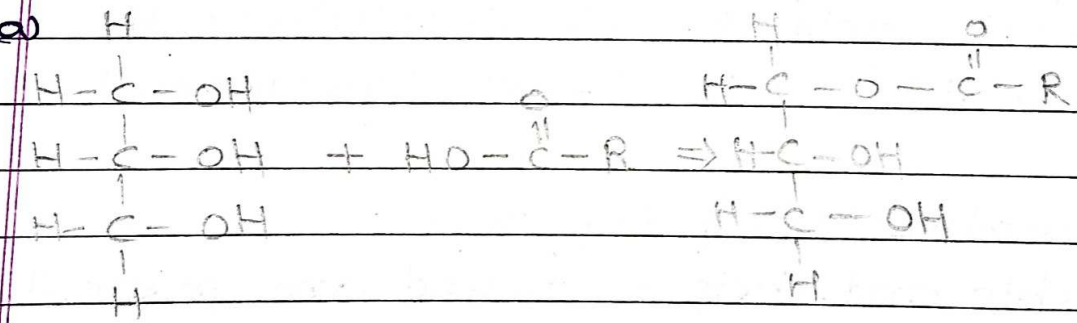
ex÷ oleic acid

- PUFA = poly unsaturated fatty acid, more than one double bound are present

ex÷ linolic acid, linolenic acid

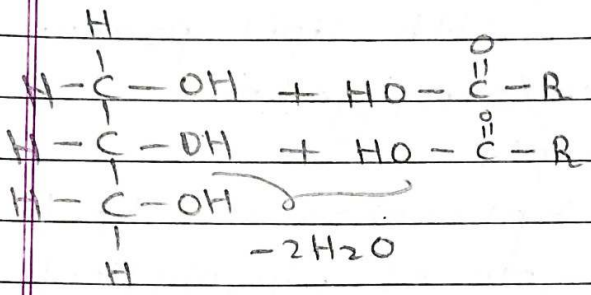
(3) Glyceride
- Glyceride is formed by adding fatty acid and glycerol
- ester bound formed

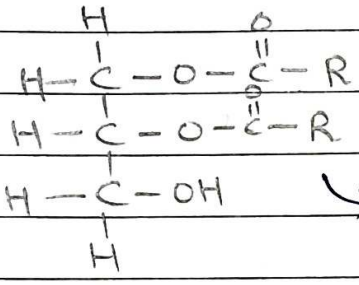
(a)



↳ one glycerol + one fatty acid

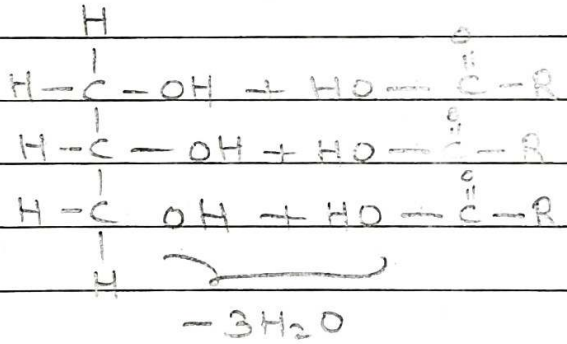
(b) Diglyceride

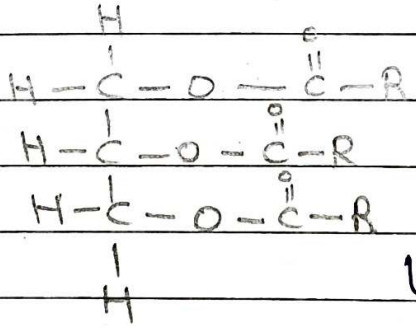




↳ one glycerol + two fatty acid

(c) Triglyceride





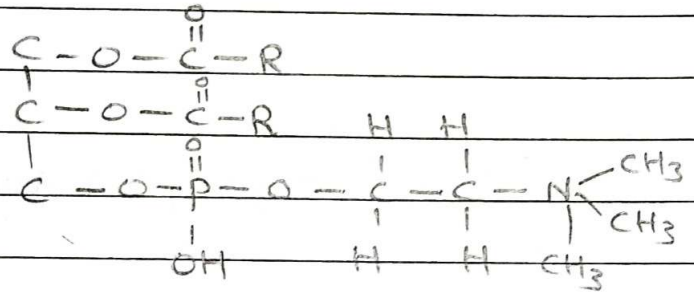
↳ one glycerol + three ~~fatty~~ fatty acid

## * Conjugated lipid

- In conjugated lipid, with lipid protein non lipid is attached/conjugated

ex: ~~phosphatit~~ phospholipid
↳ phosphorus + lipid

Lecithin is an example of phospholipid found in cell membrane

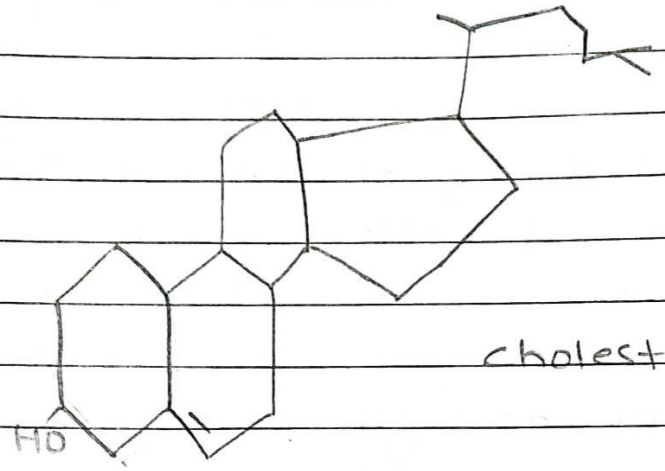


- Other conjugated lipid like sphingomyelin is found in neural tissue

## * Derive lipid

- lipid that is derived from other lipid

ex: cholestrel
cortisol
↳ sex hormone




cholesterol

* Carbohydrate
- general called as sugar
- sweet in taste mostly

- Old defination
- Carbohydrate means hydrates of carbon
- Ratio of carbon and $H_2O$ is same
- General formula = $C_x(H_2O)_y$

here $x = y$

ex: glucose (c=6)

$C_6H_{12}O_6$

But this formula and defination of carbohydrat is not universal

ex: deoxy ribose (c=5)

excepted formula = $C_5H_{10}O_5$

real formula = $C_5H_{10}O_4$

- New definition

Carbohydrate means polyhdroxy of aldehyde or polyhdroxy of ketone. so in carbohydrate two function group may present

(i) aldehyde → Aldose sugar

(ii) Ketone → Ketose sugar

aldehyde = $-\overset{O}{\overset{\|}{C}}-H$ (in terminal)

Ketone = $-\overset{O}{\overset{\|}{C}}-$ (in b/w)

* Types of carbohydrate

On the basis of number of monosaccharide obtained on hydrolysis of carbohydrate, carbohydrate is of three types

(1) Monosaccharide
↳ one

Made of one unit only

ex ÷ glucose, galactose, fructose

(2) Oligosaccharide
↳ few

On hydrolysis, oligosaccharide gives 2-9 monosaccharide.

ex ÷ Maltose, sucrose

(3) polysaccharide
(→ many)

- On hydrolysis, polysaccharide give more than 9 monosaccharide.

ex:- starch, glycogen

note:- Monosaccharide polymerize to give oligosaccharide and polysaccharide

## * Monosaccharide

- Simplest carbohydrate
- On the basis of number of carbon monosaccharide can be classified into many types.

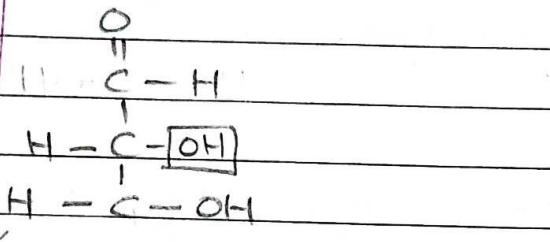
Triose → 3C
Tetrose → 4C
pentose → 5C
Hexose → 6C
Heptose → 7C

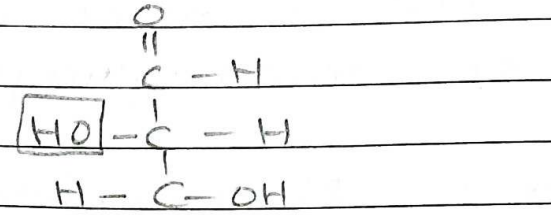
} these all monosaccharide may have keton or aldehyde as functional group

## * D and L configuration

- If on 2nd last carbon OH is present on LHS → L- configuration.

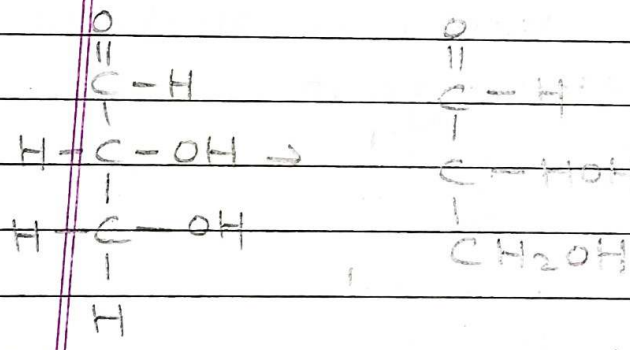
If on 2nd last carbon OH is present on RHS → D configuration



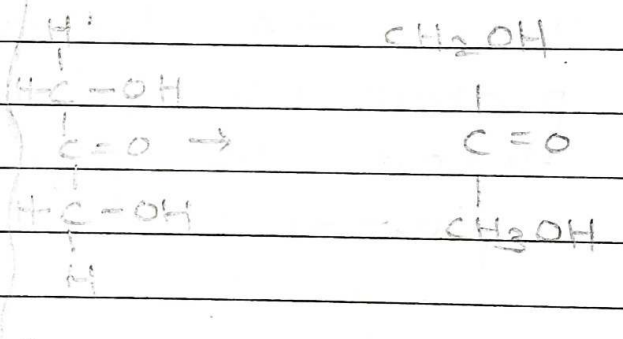

* Triose (3C)

(1) Aldotriose
· Aldehyde functional group
ex÷ glyceraldehyde



2nd C is chiral
optically active

(2) Ketotriose
· Keton functional group
ex÷ Dihydroxyacentone



2nd C is chiral
optically inactive

* Tetrose (4C)

· It can be :-

| Aldotetrose | Ketotetrose |
| --- | --- |
| → aldehyde present | → keton present |
| ex :- erythrose | ex :- erythrulose |

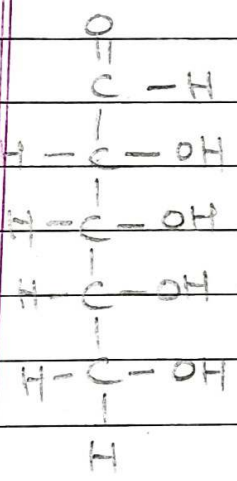
* pentose (5C)

· It can be :-

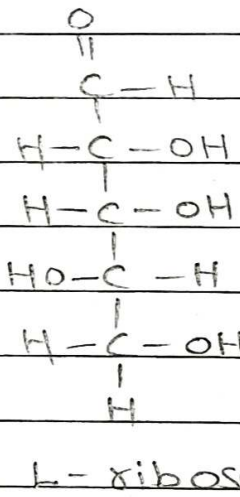
| Aldopentose | Ketopentose |
| --- | --- |
| → aldehyde present | keton present |
| ex :- ribose | ex :- ribulose |

* Ribose and deoxyribose

· Ribose



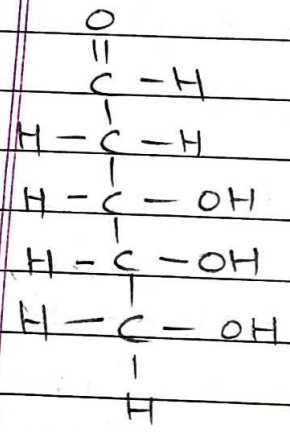
D-ribose



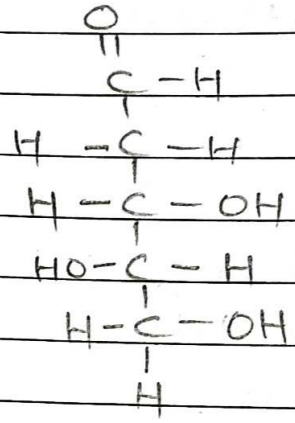
L-ribose

• Deoxyribose

• When we remove O at 2nd carbon of ribose it convert into deoxyribose

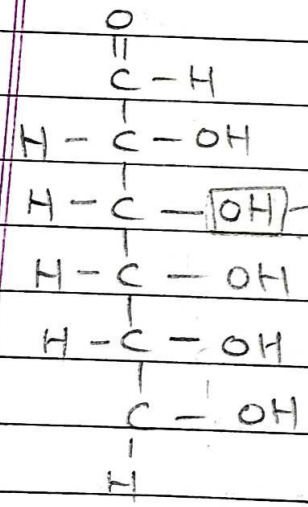


D- deoxyribose

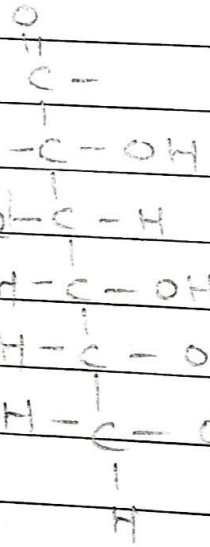


L- deoxyribose

*



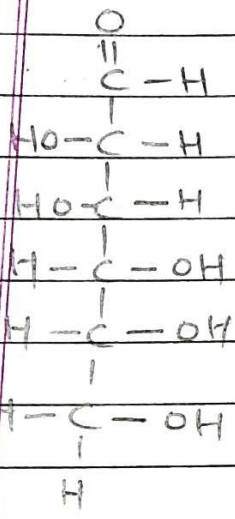
D-allose



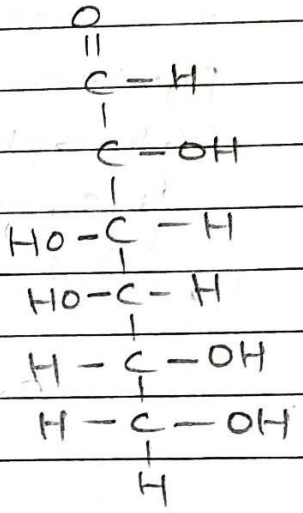
D-glucose

D-glucose

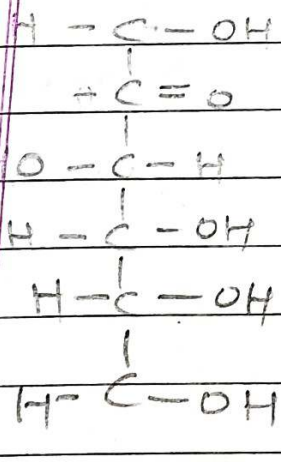
D-mannose
(change at 2nd C)



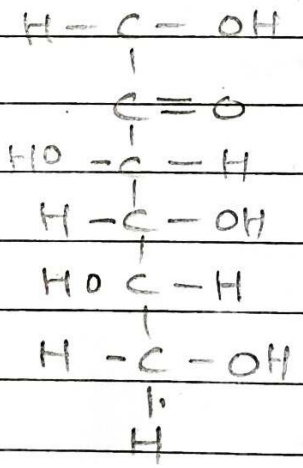
D-galactose
(change at 4th C)



* Ketohexose
→ ketone, 6C
ex: fructose
→ 2nd C = ketone,
→ change at 3rd C (OH = left, H = Right)



D-fructose

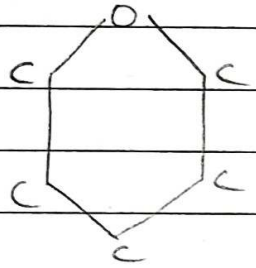


L-fructose

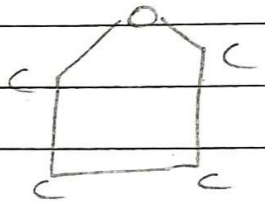
* Ring structure

Ring / cycle

Pyranose ring
- 6 members
  - 5 carbon
  - 1 oxygen

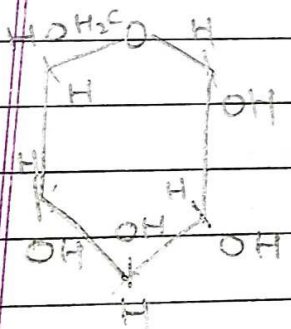


Furanose ring
- 5 - members
  - 4 carbon
  - 1 oxygen

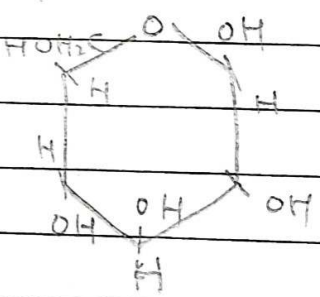


* Ring structure of glucose

α-glucose



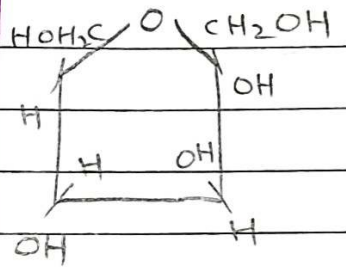
β-glucose



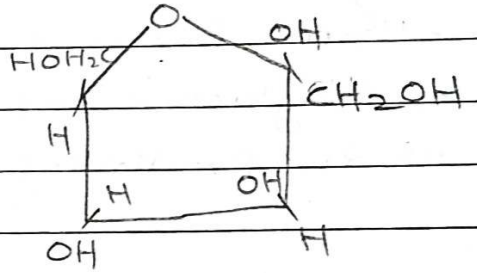
- In α-glucose OH is at down side of 1st C and in β-glucose OH is at up side of 1st carbon

* Ring structure of fructose

α-fructose




β-fructose




in α-fractose OH is on lower side of C-2

in β-fructose OH is on upper side of C-2

* Disaccharide
  - two monosaccharide joined together
  - 1 $H_2O$ molecule removed
  - O-glycosidic bound formed

Disaccharide

maltose lactose sucrose

- Matose
→ 2-α-glucose
→ α(1-4) linkage

- Lactose
→ β glucose and β galactose
β(1-4) linkage

- Sucrose
→ α-glucose and β-fructose
→ $\alpha_1 - \beta_2$ linkage

* polysaccharide

- Many monosaccharide polymerize to form polysaccharide

- polysaccharide is of two types.
(i) Homo polysaccharide
→ only one type of monosaccharide polymerize

(ii) Hetro-polysaccharide
→ More than one monosaccharide are involved in heteropolysaccharide.

* Homopolysaccharide
→ two types

(1) Storage homopolysaccharide
→ use for storing extra nutrient
ex:- glucogen, starch, inulin

(2) Structural homopolysaccharide
→ use for forming structure

* Glucogen
· Storage of homopolysacchride found in animal.
· store extra glucose in the form of glucogen → in animal
· homopolymer of α-glucose
· linkage in glycogen

- α(1-4) found linear
- α(1-6) at the site of branching

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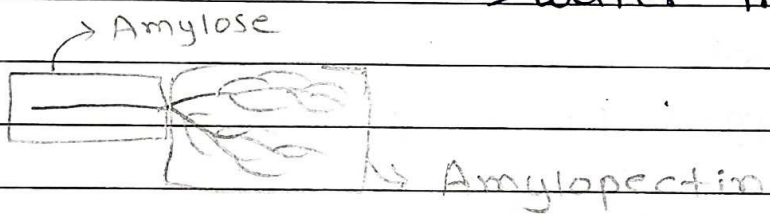
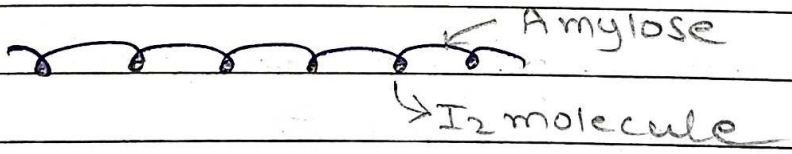
* Starch
→ Storage of homopolysaccharide found in plant
→ homopolysaccharide of α-glucose
→ Store extra glucose in the form of starch in plant.
· α(1-4) linkage found linearly
α(1-6) linkage at the site of branching
· Starch is more branched then glycogen
Starch has two portion.

(a) Amylose
→ linear portion
→ only α(1-4) linkage
→ water soluble

(b) Amylopectin
→ includes branch
→ both α(1-6) and (1-4) linkage is found
→ water insoluble




note: Starch give +ve charge in Iodine test because its amylose protein formed structure which trap Iodine molecule and give blue-black color



* Inulin
- homopolymer of fructose
- found in root of Dohia plant
- use in Renal fructose test
  ↳ healthy kidney excrete 100% inulin

* Structural homopolysaccharide

(1) Cellulose
- found in cell wall of plant
- β(1-4) linkage and O-glycosidic bound found

(2) Chitin
- found in exoskeleton of Arthropoda
- homopolymer of NAG

* Hectropolysaccharide
- Made of many types of monosaccharide
- peptidoglycan
  ↳ made of NAG and NAM

Note: glucogen has two ends

- right end : reducing end, reduce Tollen's agent and fehling's agent, free OH present

- Left end → non-reducing end, no reduce possible.

## * Metabolism

- Sum of all chemical reaction taking place in our body.

Metabolism

**Catabolism**
- → breakdown of substance
- → Energy released

**Anabolism**
- → formation of substance
- → Energy is required

## * Rate of reaction

- Speed of reaction at which reaction is taking place

ex: S ⟶ P
substrate product

rate of reaction = $\frac{\Delta p}{\Delta t}$ → change in product
↳ change in time

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## * Types of Reaction

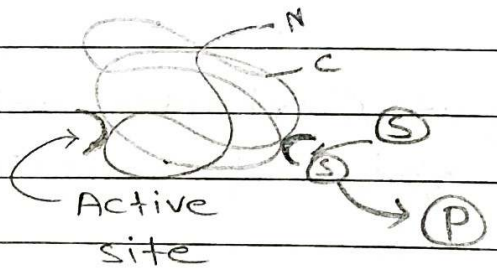
**Chemical reaction**
→ irreversible reaction
→ New bounds are formed or old bounds are broke

**physical reaction**
→ reversible reaction
→ only size, shape change

## * Enzyme

- Mostly protein in nature except ÷ Ribozyme (RNA nature)
- enzyme increase the rate of reaction
- Enzyme exist at primary, secondary or tertiary level but enzymes are active at tertiary level

- Tertiary level enzyme
→ folding of backbone of amino acid
→ has pockets or crevices or active site
→ These active site is complementary to the substrate.



- Enzymes and inorganic catlyst both increases rate of reaction.

Enzymes
↳ can't tolerate high tem. or high pressure

Inorganic catlyst
↳ can work effeciently even at high tem. and high pressure

- Organism that living in extreme hot regions have thermostable enzyme (work at high temperature)

* Example of enzyme

In reaction $H_2O + CO_2 \longrightarrow H_2CO_3$
no enzyme
200 molecule of $H_2CO_3$ formed per hour

When we use carbonic anhydrase (enzyme)
$H_2O + CO_2 \xrightarrow{C.A} H_2CO_3$
6 lakh molecule of $H_2CO_3$ is formed per sec

- Conclusion :- Carbonic anhydrase increase rate of reaction by 10 million - times

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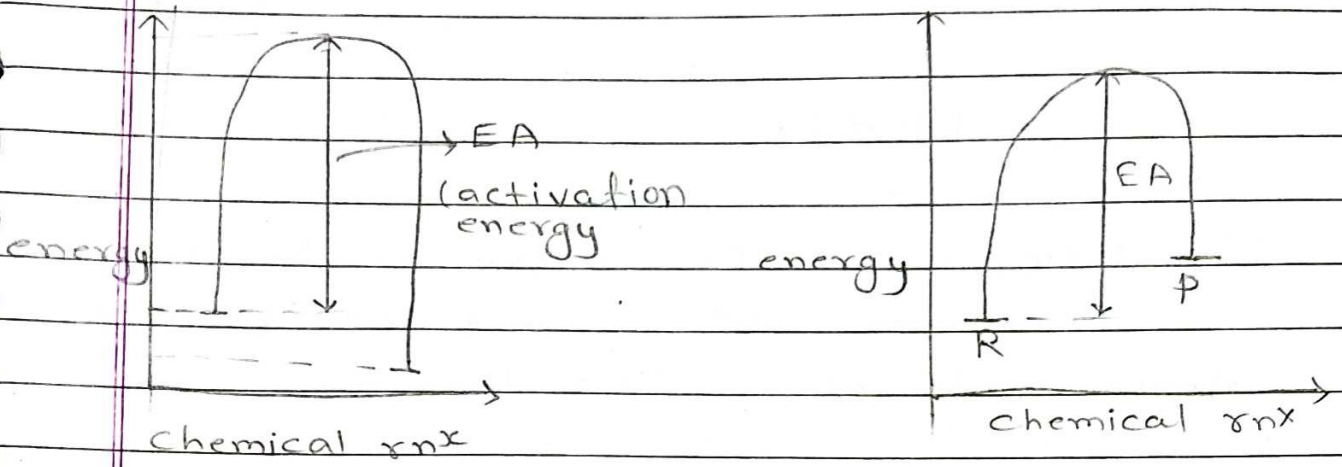
## * How enzyme increase the rate of reaction?

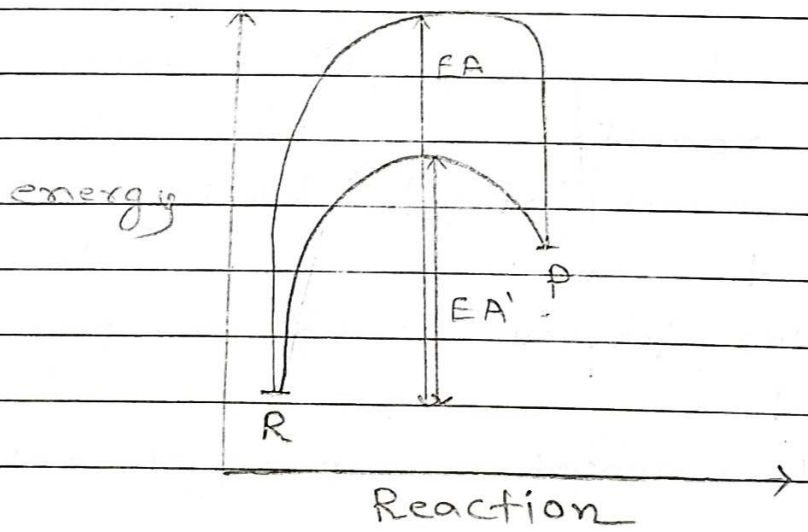



- Exothermic rnx
- $E_R > E_p$
  energy ↳ energy of product of Reactant
- Energy released

- Endothermic rnx
- $E_R < E_p$
- energy required

- Enzyme increases rate of reaction — by — decreasing activation energy

- Activation energy ÷ Minimum amount of energy require by substrate to get converted into product.



$E_A$ = activation energy in absence of enzyme
$E_A'$ = " " " presence of enzyme

$$E_A' < E_A$$

· Conclusion ÷ $E_A' < E_A$, more number of reactant will convert into product. Hence, rate of reaction increases

* Mechanism of enzyme action

| Lock and key theory | Induce fit theory |
| --- | --- |
| Complementarity b/w active site of enzyme and binding site of substrate | Substrate bind to active site of enzyme |
| ↓ | ↓ |
| Substrate bind to active side of enzyme | induce change in the shape of the enzyme |
| ↓ | ↓ |
| ES complex (enzyme-substrate) is formed | more tightly binding of E and S |
| ↓ | ↓ |
| Chemical reaction (substrate ⟶ product) | ES complex formed |
| ↓ | ↓ |
| Ep complex formed | Chemical reaction |
| ↓ | ↓ |
| product released | Ep complex formed |
| | ↓ |
| | product release |

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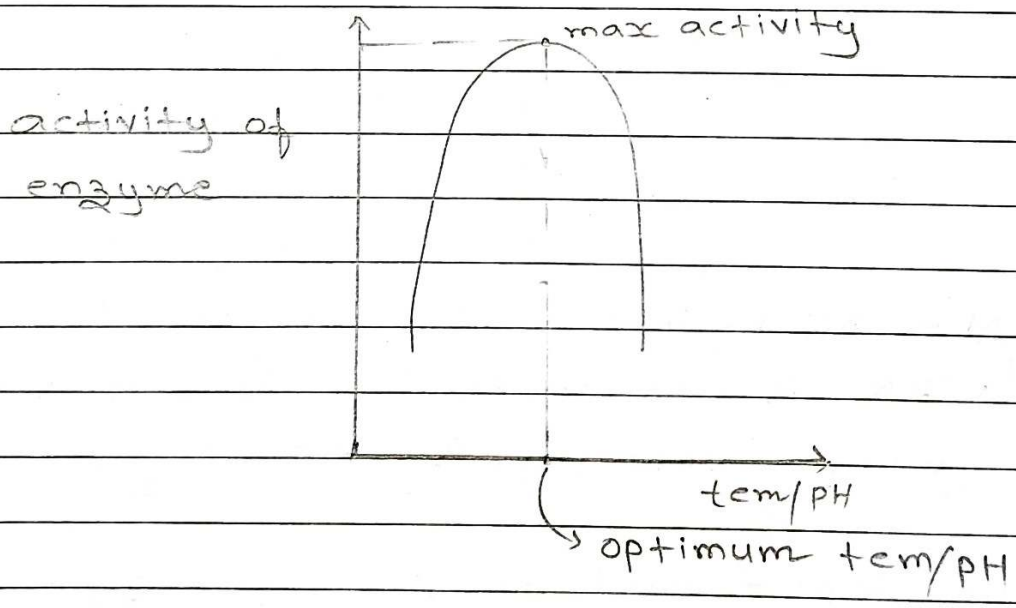
# * Factor affecting enzyme activity

(1) Temperature and pH
(2) Concentration of substrate
(3) Inhibitor

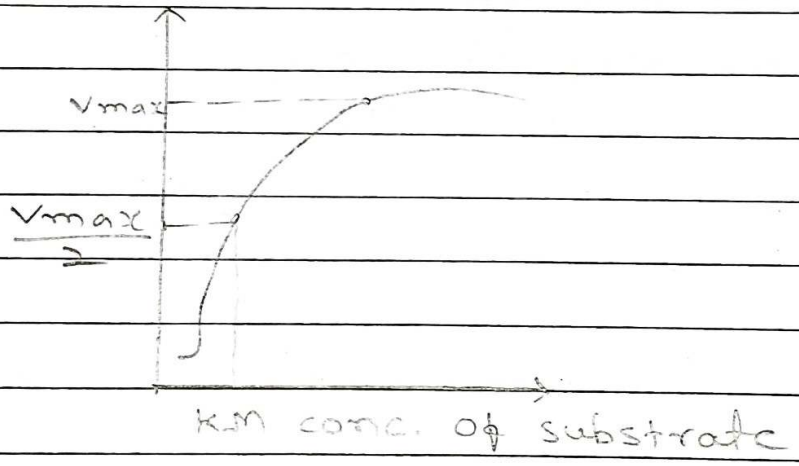
## (1) Temperature and pH

- Enzyme works maximum ~~maxium~~ at optimum temp. and pH.
- Below or above the optimum, the activity of enzyme decreases.
- low temp. ∴ enzyme inactive (preserve)
  high temp ∴ enzyme is denatured.
- Bell shaped graph is obtained for tem/pH and activity of enzyme.



(2) Concentration of substrate

- Initially, when concentration of substrate is increases, then velocity of reaction is also increases.
- But a times comes, when all enzymes is occupied by substrate. The velocity at this time point is called Vmax.
- further increase in substrate concentration will not cause rise in velocity of reaction.
- Sigmoid (s-shaped) graph is obtained in this case.




KM = Michelie menten constant.
↳ KM is concentrate ion of substrate where velocity is ~~Vam~~ Vmax/2

- low KM = good activity of enzyme
- high KM = bad " " "

(3) Inhibitor

→ Chemical that inhibit the activity of enzyme.

→ Inhibitor is of two types

(a) Competetive inhibitor

- inhibitor resemble the substrate
- inhibitor bind to active site of enzyme
- Substrate can't bind to active site
  - ↳ Es complex decreases
  - ↳ rate of reaction decreases

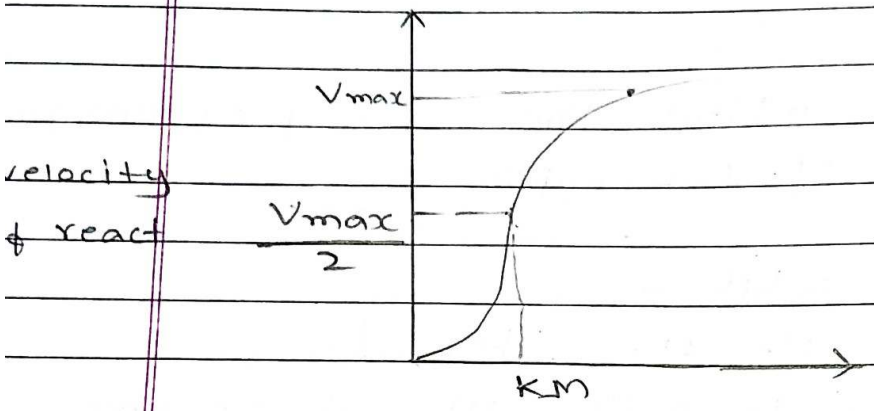
ex÷ enzyme ÷ Succinic dehydrogenase
Substrate ÷ Succinate
inhibitor ÷ Malonate

~~(a)(b) Non-competetitive~~

(b) Non- competetive

- inhibitor bind to enzyme other than active site of enzyme and change the shape of enzyme.

- Substrate can't bind to the active site
  - ↳ Es complex decreases
  - ↳ rate of reaction decreases




## Classification and nomenclature of enzyme

- 1000s of enzymes are found in nature. Which is classified into six classes a/c to the reaction they perform.

- Each class may have 4-13 subclasses. Always the sequence of classes remain same

(1) Oxidoreductose
→ Dehydrogenase
→ Enzyme catalysing oxidoreduction reaction

$$\underset{(ox)}{S} + \underset{(re)}{S'} \longrightarrow \underset{(re)}{S} + \underset{(ox)}{S'}$$

(2) Transferase

→ Enzyme catalysis
↳ tranfer of group (other than hydrogen) from one substrate to other.

$$\underset{|}{S} + S' \longrightarrow S + \underset{|}{S'}$$

(3) Hydrolase

→ Enzyme catalyzing breaking of bound with the help of $H_2O$

(4) Lyase

→ breaking of bound without use of $H_2O$
→ formation of double ~~bound~~ bond

(5) Isomerase

→ Enzyme catalysing isomerization

(6) Ligase

· Enzyme catalysing reaction in which new bond is formed
like C–C, C–S etc.

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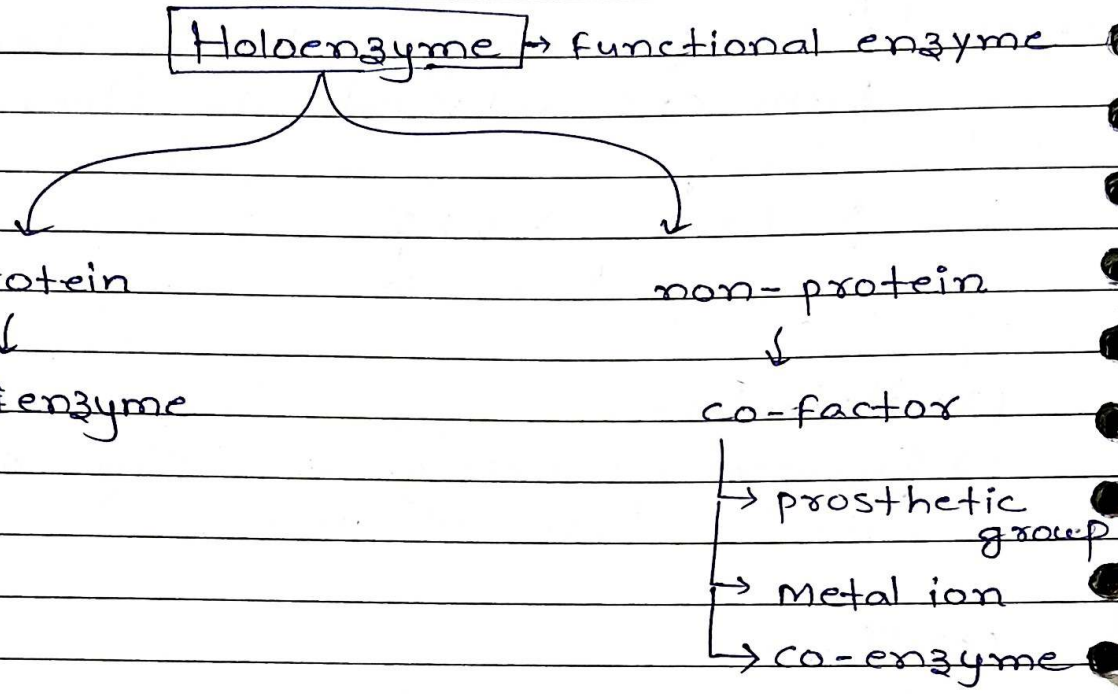
## * Holoenzyme




- Prosthetic group :- · organic in nature
  · tightly bound to apoenzyme
  · ex :- catalase, peroxidase